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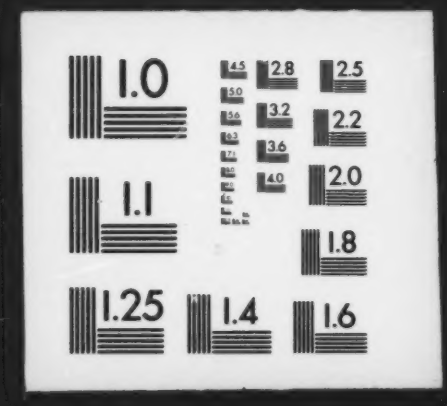

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Akron Univ., OH

Prepared for

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16. ABSTRACT

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On the basis of available aerometric information it is concluded that SO_2 in combination with NO_2 is primarily responsible for the reduction in lung function tests and the exacerbations seen in the children at the Seiberling school.

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AIR POLLUTION AND HEALTH EFFECTS IN CHILDREN RESIDING IN AKRON, OHIO

by

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FOREWORD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our Nation's population.

The Health Effects Research Laboratory, Research Triangle Park, conducts a coordinated environmental health research in toxicology, epidemiology, and clinical studies using human volunteer subjects. These studies address problems in air pollution, non-ionizing radiation, environmental carcinogenesis and the toxicology of pesticides as well as other chemical pollutants. The Laboratory participates in the development and revision of air quality criteria documents on pollutants for which national ambient air quality standards exist or are proposed, provides the data for registration of new pesticides or proposed suspension of those already in use, conducts research on hazardous and toxic materials, and is primarily responsible for providing the health basis for non-ionizing radiation standards. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of health care and surveillance of persons having suffered imminent and substantial endangerment of their health.

This report describes the effects of ambient air pollutants on respiratory function, incidence, and severity of acute respiratory illness, nature of pulmonary epidemiology, and trace element accumulation, in 4th, 5th, and 6th grade school children in Akron, Ohio.

F. G. Hueter, Ph.D.
Director
Health Effects Research Laboratory

ABSTRACT

The purpose of this study was to determine the effects of ambient air pollutants on respiratory function, incidence, and severity of acute respiratory illness, nature of pulmonary epidemiology, and trace element accumulation, in 4th, 5th, and 6th grade children in Akron, Ohio.

Air pollutants were measured at three locations and included sulfur dioxide (SO_2), nitrogen dioxide (NO_2), total suspended particulates (TSP) and from the Hi-Vol filters, suspended sulfates ($SO_4^=$) and suspended nitrates (NO_3^-). The filters and bubblers were run on a daily twenty-four hour schedule and chemical analyses were carried out by Community Health Assessment Monitoring Program (CHAMP) contractors.

All physiological and epidemiological data were collected at Seiberling and Betty Jane grade schools, in Akron, Ohio, both of which are located on the eastern edge of the city and adjacent to industrial complexes.

The aerometric results indicate significant differences between the schools for the annual means of SO_2 and NO_2 with the Seiberling school having been exposed to the higher values.

The questionnaire results indicate that the Seiberling children report more wheezing in the chest, and shortness of breath than the Betty Jane children. Daily symptoms reported by the students indicate that the Seiberling children report twice as many incidences of upper respiratory

symptoms including rhinitis, cough, and sore throat.

Trace metal analysis in hair showed that the Seiberling males have higher lead levels; both males and females have higher mercury levels but females have lower levels of cadmium when compared to Betty Jane children. However, none of the trace element levels can be considered abnormally high.

Baseline lung function testing did show that the ratio FEV_1/FVC was significantly lower ($P < .1$) at the Seiberling school. For both schools there was a decrease in lung function during the symptomatic phase of an acute respiratory illness (ARI), and the tests further indicate that the ARI's in the Seiberling school were more severe and/or involved the small airways more so than the ARI's at the Betty Jane school. Recovery from the ARI's were not complete after nine days with the Seiberling children showing slower recovery than the Betty Jane children.

On the basis of available aerometric information it is concluded that SO_2 in combination with NO_2 is primarily responsible for the reduction in lung function tests and the exacerbations seen in the children at the Seiberling school.

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LIST OF ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

TSP	-- total suspended particulates
CNS	-- central nervous system
PFT	-- pulmonary function testing
FVC	-- forced vital capacity
FEV_1	-- forced expiratory volume - one second
MMF	-- maximal midexpiratory flow
COLD	-- chronic obstructive lung disease
ARI	-- acute respiratory illness
SPSS	-- Statistical Package for the Social Sciences
TMH	-- tetramethyl ammonium hydroxide
CHAMP	-- Community Health Assessment Monitoring Program
r	-- correlation coefficient
NAAQS	-- National Ambient Air Quality Standards

SYMBOLS

SO_2	-- sulfur dioxide
$SO_4^=$	-- sulfate
NO_2	-- nitrogen dioxide
NO_x	-- nitrogen oxide
CO	-- carbon monoxide
N_2O	-- nitrous oxide
NO	-- nitric oxide
NH_3	-- ammonia
NO_4^+	-- peroxonitrate
NO_3^-	-- nitrate
NH_4^+	-- ammonium
Pb	-- lead
Cd	-- cadmium
Hg	-- mercury
Se	-- selenium
As	-- arsenic

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Section 1
INTRODUCTION

ACUTE RESPIRATORY ILLNESS (ARI) IN CHILDREN -

Air pollution continues to be a problem confronting urban and industrial population of the world. As the consumption of energy increases, the amount of pollutants produced by fossil fuel combustion will continue to increase. Furthermore, there will be a shift from oil toward coal which will increase total suspended particulates (TSP) and sulfur dioxide (SO_2). One of the perplexing problems facing our society is how much recovery or removal from stack gas of these pollutants is necessary to protect public health? Such pollutants have been shown to affect a number of human organ systems, the most susceptible being the respiratory system.

There is a large body of evidence that suggests that air pollutants are associated with an increased incidence of both upper and lower respiratory disorders. Early work by Rosenbaum (1) showed that urban recruits suffered more respiratory infections than rural recruits. Work done in the United States (2, 3, 4), and England (5, 6) have shown that both severity and incidence of acute respiratory illness (ARI) are related to high levels of one or more airborne pollutants.

Ventilatory functions have also been shown to be affected by air pollutants. These effects have been shown most dramatically in children. While many studies have shown significant losses of pulmonary function due to pollution (7-11) others have not (12, 13). This paradox could be due to a

number of factors including the level of airborne pollutants, compounding factors such as cigarette smoking, and secondary exposure to irritating substances or dust which have not been controlled in the experimental design.

Of all the industrial emissions SO_2, nitrogen dioxide (NO_2), and TSP appear to be particularly detrimental to the upper and lower respiratory system, and as such are of specific importance. Many studies have shown strong positive relationships between one or more of the pollutants to increased mortality and morbidity (14-17). Several recent reviews provide extensive information covering air pollution and epidemiological studies and are suggested in light of this limited introduction (18, 19).

The purpose of this work is not to repeat the studies mentioned above, but to incorporate various data gathering procedures and facets of these other studies into one comprehensive work. This study was designed to examine the morbidity rates of children in areas with high and low levels of air pollution to determine how the illness affects lung functions, and to carefully monitor the air pollutants that may be producing exacerbations.

Although pulmonary function testing is a major component of this work it is by no means the only aspect. Trace metal analysis and aerometric determination are also an integral part of this study. For this reason a brief description of recent, pertinent research will be presented on these topics.

TRACE METALS IN HAIR

The use of human hair for the analysis of trace metal content may be a useful tool in assessing human exposure to these metals as environmental pollutants. Hair is a metabolic end product and therefore should give some

indication of trace metal absorption and body burden. The sulfide and disulfide groups on the amino acid cysteine in follicular protein (keratin) binds heavy metals somewhat irreversibly (20, 21, 22). Sources of heavy metal deposition in hair may be both exogenous (atmospheric pollution, dust, and cosmetics) and endogenous (ingestion and absorption from inhalation) (23). Some metal ions and compounds from exogenous sources are only loosely bound or embedded in hair lipids and must be removed by meticulous washing procedures (21,23).

In this study trace metals were analyzed by atomic absorption spectrophotometry, and include arsenic, cadmium, lead, mercury, beryllium, and selenium. Each will be briefly discussed.

Arsenic

Levels of arsenic have been shown to be dependent on or correlated with geographic proximity to industrial sources and smelting operations. In growing children, subacute arsenic poisoning from a contaminated water supply has been associated with recurrent bronchopneumonia, bronchiectasis, abnormal skin pigmentation and peripheral vascular changes (24). Normal levels in children as detected by atomic absorption spectrophotometry, have been reported as less than 1 ppm (23, 25).

In 1977 Baker et al. (25) did a nationwide survey of heavy metal absorption in children 1-5 years of age who were living near non-ferrous smelters. They analyzed blood, hair, and urine in 1,774 children. In the smelter towns, hair arsenic was significantly higher than a group of control children. Hair arsenic levels most accurately indicated geographic proximity to the smelters with the arsenic levels decreasing as the distance increased.

Urban residence has also been shown to be associated with higher levels of arsenic (23, 25). The increased load was assumed to be due to absorption through the gastrointestinal tract and respiratory system since both soil and air levels of arsenic were elevated.

A very important source of arsenic pollution could be associated with coal combustion in urban power facilities. Bencko (26) has shown that arsenic levels in hair of young boys was higher near power plants when compared to a similar sample outside of the study area.

Cadmium

Cadmium is an important industrial metal used in electroplating and in the manufacture of cadmium-nickle batteries. According to Brancato et al. (27), cadmium in the hair correlates well with levels in the liver and kidney. This study was done with rats in which the cadmium load came from drinking water. Accumulation and storage of cadmium in organs is related to protein binding and renal excretion. Absorbed cadmium combines with the low molecular weight protein metallothionein, which is stored predominately in the liver and kidney. In this binding scheme, metallothionein contains cysteine which binds the cadmium. Biosynthesis of the metallothionein increases as the body burden of cadmium increases and thus more cadmium is stored in the liver and kidney. However, as exposure increases, the metallothionein biosynthesis is maximally induced and the cadmium binding sites are saturated. Cadmium ions in the kidney may then interfere with enzyme mediated tubular readsorption of metallothionein and cause its increased urinary excretion. This appears to be the mechanism resulting in proteinuria among cadmium exposed workers.

Oleru (20) showed that inhalation is the most critical route for trace metal absorption, but found no significant correlation between hair and lung cadmium levels. This is not surprising since there are no cadmium binding sulfide groups in the protein of lung matrix and elastin and in the mucocilliary apparatus of the respiratory system. As mentioned earlier, cadmium in the hair correlates well with liver and kidney levels (27), and Norborg and Nischiyama (28) also show good correlation between hair and whole body cadmium.

In a later study Oleru (29) found that lung cadmium is positively correlated with kidney cadmium but lung cadmium is not correlated with levels of the metal in liver and hair. He suggests two possible reasons: 1) the kidney is the preferred depository site for inhaled cadmium perhaps by direct passage of the metal from lung to kidney, 2) by the time inhaled cadmium reaches the liver or hair it has been depleted by passage through intermediary tissue and thus correlates poorly to its original level.

Chronic low level cadmium by way of inhalation has induced emphysema, bronchitis, and renal tubular proteinuria (30). Cadmium exposure has also been associated with anemia, hypertension, osteomalacia, and osteoporosis (24). Normal hair values measured by atomic absorption spectrophotometry are about 1.0 ppm (23, 25, 29, 31).

Lead

Inorganic lead compounds have a critical effect on the hematopoietic bone marrow which is manifested by adverse interference with heme synthesis.

Central nervous system (CNS) effects (encephalopathy) from lead exposure in children are most commonly associated with the presence of pica.

It has been suggested that less severe or subclinical effects of lead on the CNS in children is related to a slight loss in intelligence, hyperactivity, and loss of fine motor function (30). Normal hair levels using atomic absorption spectrophotometry are usually given at 15 ppm or less (23, 25, 31, 32).

The concentration of lead in hair of children residing around non-ferrous smelters has been an area of considerable interest. Several authors (31, 32, 33) have found elevated levels of lead in the hair of children residing in smelter towns. Hammer et al. (23) found, as with the other metals, that as the distance from the source increased the lead levels decreased. Several authors (21, 31) have shown that in urban communities there were higher hair lead levels than in a control rural population.

Mercury

Short term exposure to high concentrations of mercury vapor primarily affect the lung and secondarily the central nervous system. Long term occupational exposure to mercury vapor and its associated organic and inorganic salts most commonly results in disorders of the central nervous system. Proximal tubular damage and proteinuria have also been shown in exposed workers (30).

Poisoning by methyl mercury compounds results in neurological disturbances. Disturbances which result from short term exposures of methyl mercury are reversible, while long term exposure is generally irreversible (24).

There is not much literature available concerning the effects of elevated concentrations of mercury in urban air. Most studies only deal

with occupational exposures and as such do not apply to this work.

AEROMETRICS

As a result of the 1970 Clean Air Act, the United States Environmental Protection Agency (EPA) has promulgated the ambient air quality standards for the following pollutants: TSP, NO_x, SO_2, total chemical oxidents, hydrocarbons, and CO. Of these TSP, NO_x, and SO_2 are the pollutants which are normally associated with the respiratory system and are of primary concern in this work. Table 1 gives the Federal and Ohio ambient air quality standards. In their establishment, the primary standards were set "to protect the public from adverse health affects" and the secondary standards were set "to protect the public welfare from any real or anticipated adverse affects". Ohio generally chose to make the federal secondary standard their primary standard.

Table 1. National Ambient Air Quality Standard (NAAQS)

Pollutant		Primary (34) Standard	Secondary (34) Standard	Ohio (35,36) Standard
TSP	Annual geometric mean	75 $\mu g/m^3$	60 $\mu g/m^3$	60 $\mu g/m^3$
	24 hour	260 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$
NO_2	Annual average	100 $\mu g/m^3$	100 $\mu g/m^3$	100 $\mu g/m^3$
SO_2	Annual average	80 $\mu g/m^3$		60 $\mu g/m^3$
	24 hour	365 $\mu g/m^3$		260 $\mu g/m^3$

In addition to the National Ambient Air Quality Standards, the levels at which the air quality reaches a level which constitutes imminent and substantial danger to human health have been established. Collectively designated as the "Pollutant Standard Index" (PSI), it has been

recommended by the U.S. EPA (37) and is presented in greater detail in an EPA guideline document (38). Table 2 summarizes the five pollutants which make up the index, the health effects and index value.

Since this report deals with only three air pollutants and the various levels and health effects of each, a short description of these pollutants will be presented.

The Total Suspended Particulates

TSP are defined as small particles (solid or liquid) which are suspended in the air. The particles come from both anthropogenic emission and natural sources. Typical concentrations of TSP range from 20-30 $\mu g/m^3$ in clean air to 60-200 $\mu g/m^3$ in urban air. In highly polluted air TSP values are over 2,000 $\mu g/m^3$.

To illustrate the various levels of TSP in the study areas, some United States EPA data will be presented. Akron had four stations reporting annual mean values of 80, 76, 70, 112 $\mu g/m^3$, with maximum values reaching 164, 149, 186, and 232 $\mu g/m^3$, respectively. In Cleveland there were six stations reporting mean annual values in $\mu g/m^3$ of 201, 126, 168, 113, 156, and 133 with maximum values of 528, 412, 407, 243, 392, and 403, respectively. Rural areas in Ohio had annual averages which ranged from 48 to 58 $\mu g/m^3$ (39).

Sulfur dioxide

SO_2 in the atmosphere comes from both natural sources and anthropogenic sources. Of the anthropogenic emissions more than 95% comes from fossil fuel combustion and industrial processes. Also since the anthropogenic SO_2 emissions are primarily the result of fossil fuel combustion, high

Table 2. Pollutant Standard Index (PSI) and associated air pollutant values.

		TSP $\mu g/m^3$ (24 hr.)	SO_2 $\mu g/m^3$ (24 hr.)	CO mg/m^3 (8 hr.)	NO_2 $\mu g/m^3$ (1 hr.)	O_3 $\mu g/m^3$ (1 hr.)	Health Effect Descriptor
-50	50% of NAAQS*	75	80	5.0	No index value	80	Good
-100	NAAQS*	260	365	10.0	No index value	160	Moderate
-200	Alert	375	800	17.0	1130	400	Unhealthful
-300	Warning	625	1600	34.0	2260	800	Very Unhealthful
-400	Emergency	875	2100	46.0	3000	1000	Hazardous
-500	Significant harm	1000	2620	57.5	3750	1200	Hazardous

*National Ambient Air Quality Standards

ambient air levels of SO_2 are almost always associated with high values for TSP. They are frequently described together and referred to as the TSP/SO_2 complex.

Typical levels of SO_2 in urban areas have shown a downward trend throughout the 1960's and early 1970's but presently they appear to be leveling off at a new low level (39). In large part the leveling of the SO_2 levels has been due to the shift from high sulfur fuels to low sulfur fuels.

Nitrogen oxides

The important nitrogen species which are present in the atmosphere are nitrous oxide (N_2O), nitric oxide (NO), nitrogen dioxide (NO_2), ammonia (NH_3), and the peroxonitrate (NO_4^+), and nitrate (NO_3^-) salts. These compounds are derived from both natural and anthropogenic sources. The primary anthropogenic sources for nitrogen oxide and nitric oxide are the combustion of fossil fuels in the internal combustion engine and for generation of high pressure steam, of which the majority if used is the generation of electricity.

Nitric oxide is the oxide produced during combustion and is in the exhaust gases and stack gases. It is oxidized to nitrogen dioxide in the atmosphere. The nitrogen dioxide absorbs energy in the visible spectrum and separates to form nitric oxide and nascent oxygen. The reaction is one of the major reactions in the formation of photochemical smog.

The combined concentration of NO and NO_2 is known as NO_x. The NO_x levels have been decreasing the past few years.

This lowering of the NO_x levels has been attributed to the redesign and control of the combustion processes placed on automotive internal

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Section 2
CONCLUSIONS

Aerometric data reported in this study show that the Seiberling school has an annual mean level of SO_2 which was three times the annual average at the Betty Jane school and NO_2 levels were nearly twice as high. The data indicates that although annual averages for both SO_2 and NO_2 are below the National Standards, these air pollutants do have a significant effect on grade school children. These effects do not manifest themselves as dramatic reduction in forced vital capacity (FVC) or forced expiratory volume (FEV_1) recorded at baseline conditions. However, one calculated pulmonary function parameter FEV_1/FVC which is a percentage of the vital capacity expired in one second, did indicate that the children residing in the polluted area have some reduction in pulmonary efficiency.

Pulmonary function testing during acute respiratory illness (ARI) did reveal some interesting and highly significant results. During episodes of ARI it appears as though the upper and/or lower respiratory infections are being compounded by the effects of air pollution. This compounding effect produced significant reductions in the pulmonary function flow parameters, FEV_1 and maximal midexpiratory flow (MMF), in the Seiberling children when compared to the Betty Jane children. The reductions in pulmonary functions also appear to take longer to return to baseline values in the Seiberling children. Additionally, the Seiberling children consistently report higher incidences of daily upper and lower respiratory

symptoms.

It is concluded that these children residing in the Seiberling area are exposed to levels of air pollutants which are currently affecting lung functions and producing increased symptomology and with long term exposure it is suggested that such levels of air pollution could lead to chronic obstructive lung disease (COLD).

Section 3
RECOMMENDATIONS

It is recommended that the annual average for SO_2 be no higher than 80 $\mu g/m^3$ or more ideally be lowered to 60 $\mu g/m^3$. In this study the level of NO_2, although quite low, does appear to be affecting the children. This may be a synergistic effect with SO_2 or it may be an individual effect. On this basis we recommend that the health effects of NO_2 be given careful consideration but we do not recommend that the Primary Standard be changed.

Section 4
EXPERIMENTAL PROCEDURES

PULMONARY FUNCTION TESTING

In the Akron area two schools were selected for study because of their close proximity to industry. Seiberling elementary school is located in the east sector of the city approximately two miles from the center of downtown and one-half mile from the closest factory. Betty Jane elementary school is located two miles east of Seiberling school.

Having received permission from the Akron city superintendent of schools to conduct our study, the research team sent home with each 4th and 5th grade child, an envelope containing the following: (Appendix 1)

1. Letter of introduction
2. Survey questionnaire to be completed by parents
3. Small envelope for hair sample

During the first year, 1976-77, seventy-four males and seventy-two females from the Seiberling school returned questionnaires and ninety-nine males and fifty-eight females from Betty Jane school. During the second year, 1977-78, seventy-four males and sixty-four females from Seiberling and ninety-four males and fifty-nine females from Betty Jane participated. This included children from the 1976-77 study as well as some new participants. In both schools the participants constituted about 85% of the total 4th and 5th grade population during the first year and 88% of the 5th and 6th grade population during the second year.

The research team then began pulmonary function testing (PFT). A Warren E. Collins 9 liter recording spirometer was used for all testing. There were two units, one at each school and each was calibrated with respect to volume by using a one liter syringe and for paper speed by using a signal marking apparatus. Both units were identical.

During the first year the PFT was carried out at both schools by two medical technologists. Both of these researchers were thoroughly familiar with the apparatus and with pulmonary function tests. Both had been coached by the principal investigator as to how to describe the tests to the children and how to demonstrate and coach the children during the maneuver.

During the second year (1977-78), the PFT and epidemiological work was conducted by four people, two at each school. Each team worked independently of the other. The only combined efforts were associated with determining the presence and severity of particular respiratory symptoms for standardizing purposes.

For baseline determinations the children were called in two at a time so that both could hear the instructions at the same time. For this initial testing each child was without any respiratory symptoms; if any were present baseline testing was delayed until the child was completely asymptomatic. They had their height (shoes off) and weight measured, were given an explanation concerning the spirometer, how it worked, and what was required of them to successfully perform a forced vital capacity (FVC) maneuver. The experimenter then gave a demonstration of the FVC maneuver. The child was then given a noseclip and connected to the mouthpiece. Several trial maneuvers were recorded and when it was felt that the recorded spirogram was satisfactory, the child repeated the maneuver

until three acceptable spirograms were recorded. If none was satisfactory, the child was asked to return on another day for a retest. Between eight and ten children from each school were dropped because of their inability to adequately perform the FVC maneuver. From each spirogram the following values were calculated, forced vital capacity (FVC), forced expiratory volume - one second (FEV_1) and maximal midexpiratory flow (MMF).

Following completion of the baseline values the experimenters began the acute respiratory illness (ARI) testing phase.

In order for the experimenters to get some idea of an ARI that was in progress, the students were asked to fill out a daily symptom chart during the morning home room period. These were collected every other day, examined for potential ARI's and then returned to the home room teacher. During the early weeks of the 1976-77 year it was noticed that nearly all of the students were checking all of the symptoms for each day. Initially it was thought that the students were checking the symptoms because of the novelty of the chart. Even after a month of examining the charts and examining the students for the symptoms it was realized that the novelty had not worn off. The symptom chart format was then changed to include "yes-no" answers for each symptom. This format allows the students the opportunity to continue checking the chart but provides more accurate information. The improvement in data quality was immediate and enabled the investigators to accurately isolate the students with ARI's so that lung function testing could be initiated. Both of these symptom charts are shown in Appendix 2.

On days when "runny nose" as well as two other symptoms were reported, the child was called to the clinic where he/she was observed,

questioned, and the reported symptoms were verified. If it was felt that the child did not have an ARI the child was again reinforced as to what the characteristics of the symptoms were and when to report them. Some of the children were chronic reporters and had only minor symptoms while others had chronic symptoms. In the latter situation the investigators mutually compared students so that symptom severity could be determined in a standard manner. In the former case, the students were not included in the ARI testing phase. Once an ARI was identified, the child was called to the clinic every other day until he/she was completely asymptomatic. From this first asymptomatic day, PFT were then run every other day until the ninth asymptomatic day. These data were called asymptomatic.

During the second year of the study (1977-78) a considerable number of improvements were made. First, as previously described, the symptom chart was revised, giving more accurate assessment of each child's symptoms. Second, PFT were done twice during the symptomatic phase, designated Symptomatic A for the first test and Symptomatic B for the second. The child's symptoms were listed and graded as mild, moderate, or severe, directly on the spirogram. It was anticipated that the number, type and severity of the symptoms could be correlated with reduction in the pulmonary function parameters. Third, follow up second year questionnaires were sent home to be filled out by the parents. These questions were designed to determine any increases in the symptoms of chronic obstructive lung disease (COLD) over the past year. The questionnaires are shown in Appendix 3. Finally, at the end of the second year (in May) we again ran another set of baseline tests in order to have another data point with which to compare the children.

All of the spirograms were calculated using criteria such that the best value of any of the parameters was kept and two more that were within 5% of the best one. This was done as follows. For each session a child would perform a series of maneuvers which was carefully examined by the technician. When in the estimation of the technician the child had performed three similar spirograms the session was terminated. After the seventh maneuver the session was terminated regardless if there were three successful ones or not. These spirograms were then returned to the laboratory and all maneuvers were calculated and converted to BTPS. The maneuvers with the largest FVC and two others which were within 5% were kept. FEV_t and MMF values were those that accompanied the FVC. At least two values for each parameter were required or none of the data for a given child were used. All of the PFT data, vital data, and symptom data were entered and stored on disk file in the main University Computer System, an IBM 370 with associated equipment.

All of the data were first corrected to body, temperature, pressure, saturated (BTPS). The data were then adjusted using linear regression in a manner described below so that comparisons could be made both within and between the schools. Student's "t" test was used to compare the means between the schools.

Adjusted Pulmonary Function Methods and Within School Comparisons

In order that baseline, symptomatic, and asymptomatic comparisons within a school could be made, it was necessary to eliminate the effects of height, weight, and age. In both Seiberling and Betty Jane schools, height, weight, and age were regressed using males and females separately for the variables FVC, FEV_1, and MMF. The multiple linear regression

package from the Statistical Package for the Social Sciences (SPSS) (40) was used.

In most cases the effects of one or more of the independent variables, age, height, and weight were not statistically significant. A stepwise linear regression with forward order of inclusion was most convenient in looking at the effects and relative contribution of variation for the three independent variables. We chose the single independent variable or group of independent variables that produced the lowest standard error of the estimate (SEE) or smallest confidence interval.

There were two adjustment processes. When comparisons were made within a school only those data were entered into the regression matrix. When comparisons were made between schools, the data from both schools were entered into the regression matrix. Males and females were always adjusted separately.

Using these selection criteria, the appropriate coefficients were then used to adjust baseline, symptomatic, and asymptomatic pulmonary function variables using the equation:

$$PFT_{adj} = PFT + [\beta_{HE} (He - He_a) + \beta_{WE} (We - We_a) + \beta_{AGE} (AGE - AGE_a)] \quad (1)$$

where: PFT is a pulmonary function parameter (FVC, FEV_1, MMF)

PFT_{adj} is the adjusted pulmonary function parameter

β is the coefficient determined using the liner regression program

He is the subject height when the lung function is measured

We is the subject weight when the lung function is measured

AGE is the subject age when the lung function is measured

He_a height to which the subject is being adjusted

We_a weight to which the subject is being adjusted

AGE_a age to which the subject is being adjusted

Finally, the ratio of FEV_1/FVC was calculated for each subject based on the adjusted values obtained from equation 1.

Adjusted Pulmonary Functions and Between School Comparisons

In order to compare the pulmonary functions between the two schools the same statistical procedures were used except the regression coefficients were generated using baseline values from the combined schools. Again the pulmonary functions were used as the dependent variable and age, height, and weight as the independent variable. The SEE was again used to determine which were most critical in the regression equation, within a stepwise linear regression with forward order of inclusion.

TRACE METAL ANALYSIS IN HAIR

The trace metal work was carried out at the Trace Element Laboratory, Metropolitan General Hospital, Case Western Reserve University, Cleveland, Ohio and Stewart Laboratories, Knoxville, Tenn.

The preparation of the hair for analysis was initiated by two washes with ethyl ether. The hair was then thoroughly dried and 100 mg weighed out. The 100 mg sample of hair was then digested by adding 10 ml of tetramethyl ammonium hydroxide (TMH). To facilitate the digestion the mixture was kept in an oven for eight hours at 55°C. Finally a 1 ml sample of the prepared mixture was diluted 1:5 with deionized water.

All of the analyses were carried out by direct aspiration on Perkin-Elmer atomic absorption spectrophotometric equipment.

AIR POLLUTION MEASUREMENTS

The TSP levels were measured using the high volume sample procedure as described in the Federal Register, 36: 8186 (1971). The Hi-Vol and flow meters for each of the sites were calibrated using a Sierra Orifice which was initially calibrated by Environmental Protection Laboratories in Research Triangle Park, N.C. The units were operated daily for a 24 hour period beginning and ending at 8:00 a.m. Each unit had a Sierra Flow controller to maintain the flow at 1.13 m^3/min (40 cfm). The filter papers were supplied and weighed by a Community Health Assessment Monitoring Program (CHAMP) subcontractor, Stewart Laboratories, Knoxville, Tenn.

The trace elements, suspended nitrate, suspended sulfate, benzo(a)pyrine and benzene soluble organics were determined as weekly composites of the filters by Stewart Laboratories.

The NO_2 and SO_2 values were determined using the liquid phase bubbler train. The absorption solutions were supplied and analyzed by Stewart Laboratories. The bubblers were run for the same 24 hour period as the high volume sampler. The flow through the bubbler train was measured using calibrated rotometers both before and immediately after sampling. The flow through the tubes was controlled using critical flow orifice and was about 200 cc/min.

After the samples were obtained the NO_2 bottles were refrigerated and the SO_2 were frozen and shipped to Stewart Laboratories in refrigerated boxes.

The Hi-Vol motors and flow meters were changed every 4 to 5 weeks, with each being calibrated at the University of Akron using the Sierra Orifice.

The critical orifices were changed as needed to maintain the necessary flow rates.

The Seiberling station was located adjacent to the Seiberling school at ground level and along a moderately traveled city street. The expressway system was approximately 2 miles south; consequently, automotive pollution would be nominal. The Goodyear station was located one mile west within the Goodyear Metropolitan Park and also at ground level. Traffic here was nearly nonexistent except for a southern boundary street one quarter mile from the station. Traffic on the road was also moderate. The Betty Jane station was situationed on top of a ten foot roof at the school. It was placed there because this school is located next to a large stand of trees which would have formed a considerable boundary layer and altered the data. On the roof of the school the boundary layer effect was considered to have been eliminated and representative quality data could be obtained. This school is also bordered on the east by a city street with moderate traffic. Figure 1 is a map of the areas showing the location of the three stations as well as significant point sources of air pollutants.

These two schools and the associated air pollution station are located in a walking school district. Ninety-five percent of the students walk to and live within one mile of the school.

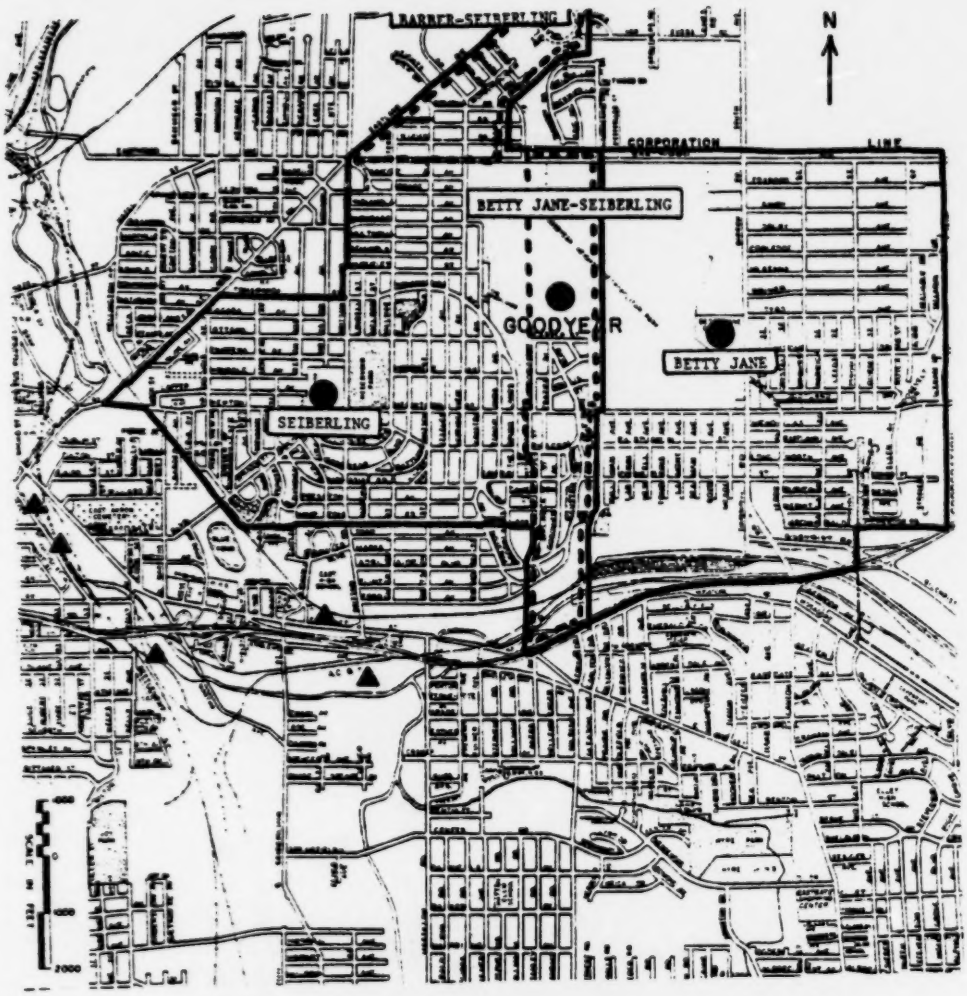

Figure 1 - Geographic locations of aerometric stations in Akron, OH. Large point sources of air pollution are indicated by triangles (▲).

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Section 5
RESULTS AND DISCUSSION

AIR POLLUTION LEVELS

The aerometric data were collected at three stations. One directly adjacent to the Seiberling school, a second on the roof of the Betty Jane school, and a third the Goodyear station was located between the two schools.

All of the data reported begins October 15, 1977, and ends September 31, 1978 and for that period the mean yearly values are shown in Table 3. The difference between the Seiberling and Betty Jane children are highly significant for all aerometric variables.

Table 3. Annual averages (Oct. 1977 to Sept. 1978) for TSP, suspended, SO_4 and NO_3, SO_2 and NO_2 in $\mu g/m^3$. ($\bar{x} \pm SE$).

	Seiberling	Goodyear	Betty Jane
TSP	68.8 ± 3.0* N=180	53.2 ± 1.8 N=165	51.6 ± 3.0 N=70
SO_2	59.6 ± 3.5* N=166	30.8 ± 3.1 N=138	18.5 ± 2.6 N=65
NO_2	48.6 ± 1.4* N=203	25.1 ± 1.2 N=170	34.5 ± 2.7 N=65
SO_4	15.0 ± 0.7* N=180	14.4 ± 0.6 N=165	11.6 ± 0.6 N=70
NO_3	4.9 ± 0.2* N=180	3.7 ± 0.2 N=165	4.1 ± 0.2 N=70

*($P < .01$)

Since there was a great deal of missing data from the Betty Jane station it was decided to compare the sites using same day samples. These

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data are shown in Table 4. These same day samples do show some reduction in the SO_2 levels for Seiberling but the levels are still substantially higher than the other two stations. All of the other pollutant trends remain consistent with the data in Table 3. Aerometric data for the year 1976-77 are not presented because of the CHAMP station had not yet been installed.

Table 4. Same day samples Oct. 1977-Sept. 1978 in $\mu g/m^3$ ($\bar{x} \pm SE$).

	Seiberling	Goodyear	Betty Jane	N
TSP	48.7 ± 3.7	44.1 ± 2.8	45.9 ± 3.3	45
SO_2	65.1 ± 6.5*	38.8 ± 6.8	18.7 ± 3.2	33
NO_2	48.8 ± 2.7*	31.0 ± 2.7	33.1 ± 2.8	39
SO_4	11.2 ± 0.9	11.1 ± 0.8	10.4 ± 0.7	45
NO_3	1.6 ± 0.2	1.2 ± 0.2	1.5 ± 0.2	45

*($P < .01$)

To conveniently compare data for air quality at the three stations, the aerometric data were compiled as monthly averages. These monthly averages are shown in Figure 2, 3, 4, and 5. NO_3 is not included because there is not much monthly variation. The missing data at the Betty Jane station is a result of a power shutdown during the Ohio coal strike in 1978.

From the annual and monthly data it is obvious that the Seiberling station has consistently higher levels of SO_2 and NO_2. In comparing the Seiberling to Betty Jane station the yearly values for SO_2 at the Seiberling station are nearly three times as high. Even though there is a great deal of missing data from the Betty Jane station, this statement is made with confidence, because the center station, Goodyear, is consistently

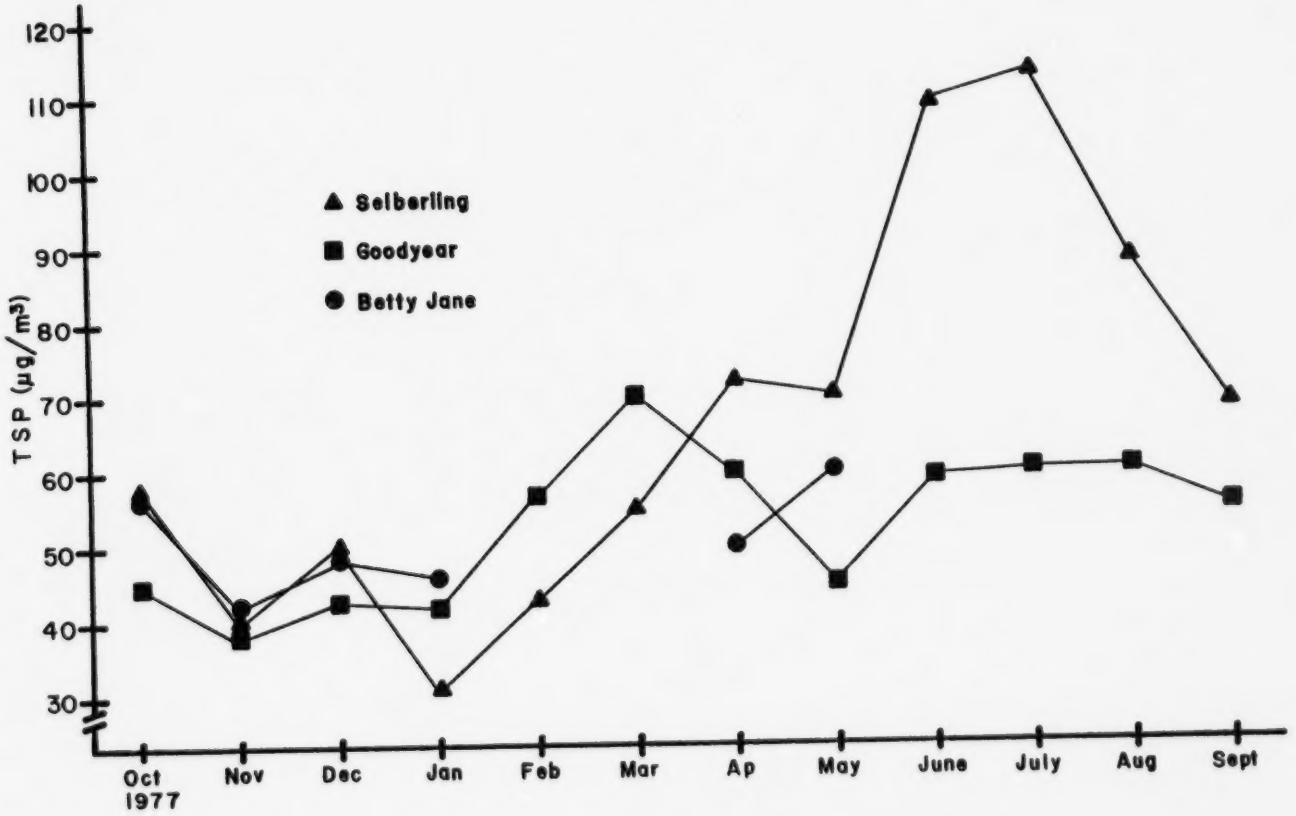

Figure 2 - Monthly mean values of total suspended particles (TSP) 1977-78.

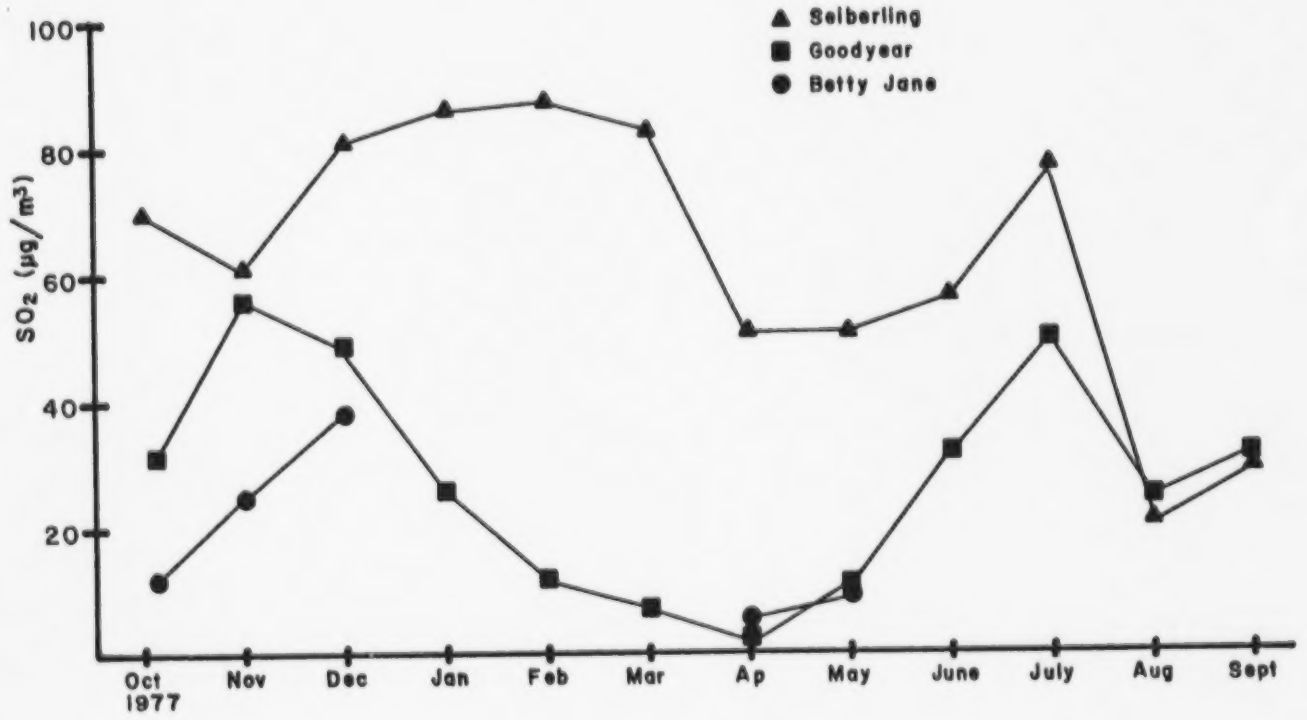

Figure 3 - Monthly mean values for sulfur dioxide (SO_2) 1977-78.

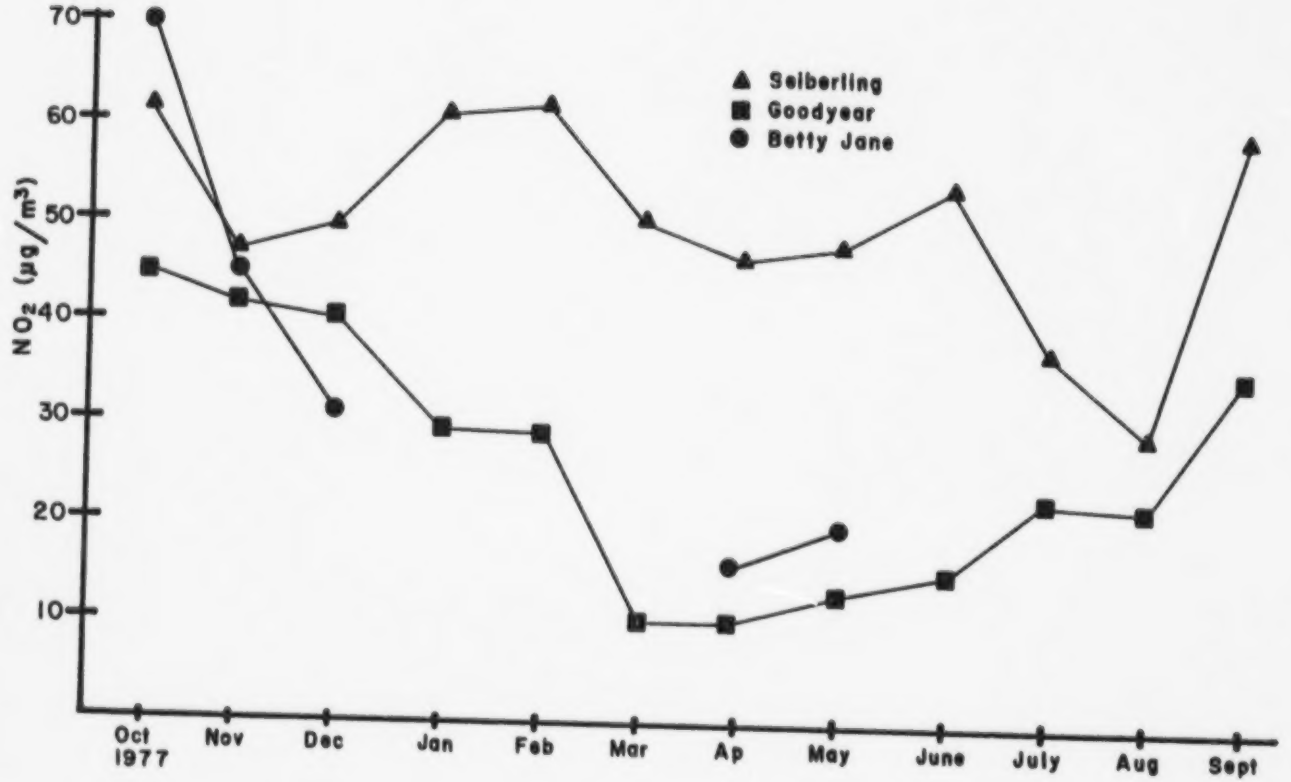

Figure 4 - Monthly mean values for nitrogen dioxide (NO_2) 1977-78.

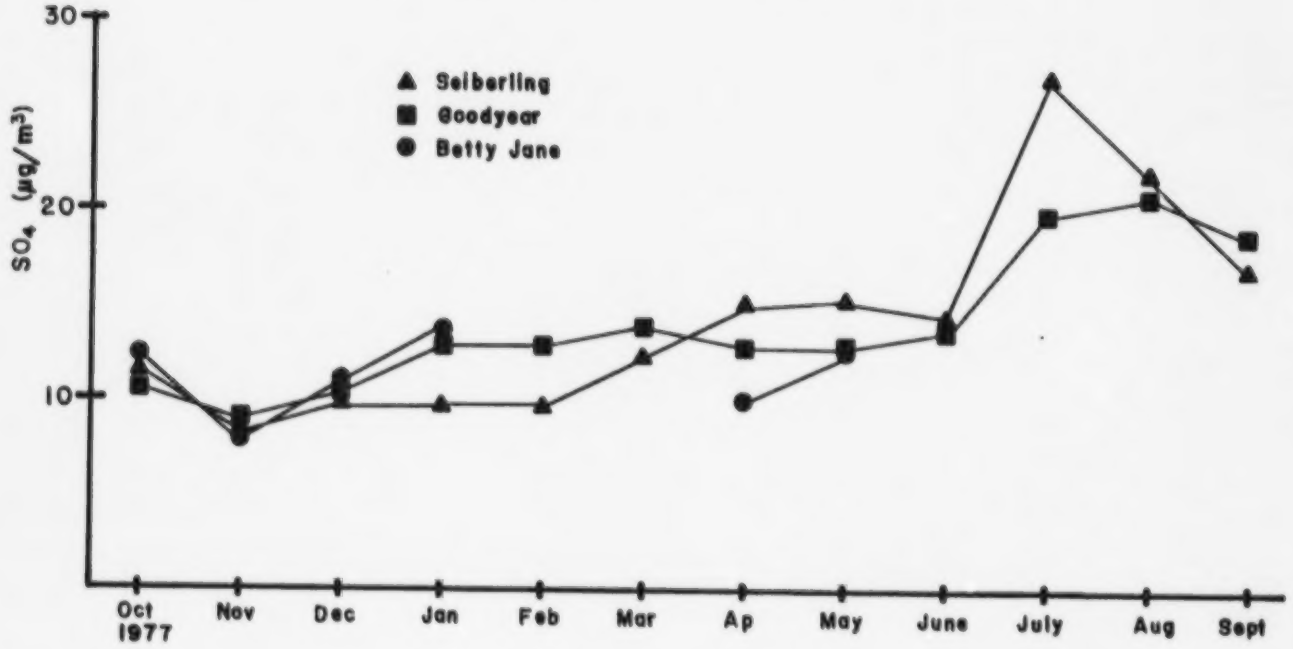

Figure 5 - Monthly mean values for suspended sulfate (SO_4) 1977-78.

lower than Seiberling but higher than Betty Jane and as such can be used as an interpretive station.

One point of disparity in these data is that the TSP do not follow the SO_2 data as would be expected. From Tables 3 and 4 and Figure 2, the levels of TSP are quite similar for all three stations with the data trend showing a rise in the monthly means from January to May. Conversely, the SO_2 and NO_2 data at Seiberling (Figures 3 and 4) show consistently elevated values over both Goodyear and Betty Jane during every month except for October and November, and monthly peaks in TSP are not accompanied by a peak in SO_2.

For the period of time that the health data were collected, the annual average values for SO_2 at Seiberling was very close to the primary standard established by the U.S. EPA (80 $\mu g/m^3$) and exceeded the Ohio EPA standard (60 $\mu g/m^3$). This would correspond to October through May in Figures 3, 4, 5, and 6.

To reinforce these aerometric data, especially at the Seiberling station, we compared our data with data from the Akron Air Pollution Control Board. The East High School station is about one-quarter mile south of the Seiberling station and also adjacent to the Akron Industrial area. These comparative data are shown in Table 5.

Table 5. Same day samples from Oct. 1977-Sept. 1978 for Seiberling and East High School aerometric station. Data are in $\mu g/m^3$ ($\bar{x} \pm SE$).

	Seiberling	East High School	N
TSP	74.0 ± 8.3	87.9 ± 6.1	30
SO_2	64.5 ± 9.2	67.2 ± 7.4	29
NO_2	46.2 ± 3.9	54.6 ± 3.7	31

The East High station is run for 24 hours every sixth day and consequently there were not many same day runs. The data do, however, point out the similarities between the two aerometric sampling groups, i.e., Akron University and the Akron Air Pollution Control Board.

The Goodyear station and Betty Jane station could not be conveniently compared because there are no stations nearby and with the complications imposed by meterology and automobile traffic such comparisons were not attempted.

Trace Metal and Organic Composite Data

These data are derived from the Hi-Vol filters as composite samples. The mean days per composite varies among Seiberling, Goodyear, and Betty Jane due to the fact that at the Goodyear station few Hi-Vol filters were used in each composite. Standard deviations are not presented in Table 6 because at the Seiberling and Goodyear stations only six composite values were reported by the subcontractor.

Table 6. Metal and organic composite results (Ng/m^3, $\bar{x}$).

	Mean days/ composite	Total N	As	Be	Cd	Hg	Pb	Se	Benzo(a) pyrine	Benzene Soluble Organics
Seiberling	14.5	175	9.24	0.57	1.44	1.51	322.5	2.02	0.84	3711.3
Goodyear	4	230	8.4	0.5	1.66	1.58	274.62	2.14	1.14	4528.2
Betty Jane	9.2	74	6.68	0.5	1.92	1.128	245.85	1.58	1.57	4716.5

PULMONARY FUNCTION TESTING

In order to verify that the socioeconomic status (SES) of the two schools were similar, socioeconomic index scores were calculated using parental occupation according to the method of Blishen (41) and Hollingshead (42). These data are shown in Table 7. The sample size is less than the total number reported in this report because only the 6th grade children were requested to supply parental occupations. As the table indicates there are no statistically significant differences in SES between the parents of the children in the two schools although control children's parents did report a somewhat higher SES index.

Table 7. Socioeconomic index scores and the percentage of both parents working and unemployed in the Akron school children study.

	N	SES Index	Standard Error	% Both parents working	% Unemployed
Seiberling Control Children	52	37.8 N.S.	± 2.34	54	4
Betty Jane Control Children	57	46.0	± 2.76	47	2

N.S.=not significant

The adjusting of PFT data was carried out with the coefficients from the regression analysis. Age, height, or weight was/were used depending on which of these independent variables determined the most variations.

Pulmonary Function Comparisons Between Schools 1976-77

The baseline pulmonary function data for the 1976-77 testing period are shown in Table 8. These data were collected under conditions when the

children were completely asymptomatic.

Table 8. Comparative adjusted mean baseline values for males and females in Seiberling and Betty Jane schools 1976-77 ($\bar{x} \pm SE$).

	Males		Females	
	Seib. N=58	B.J. N=77	Seib N=65	B.J. N=56
Ht (cm)	140.83 ± 0.90	141.77 ± 0.90	142.25 ± 0.90	142.66 ± 0.90
Wt (Kg)	36.06 ± 1.60	36.30 ± 1.10	37.52 ± 1.00	38.20 ± 1.30
Age (months)	124.63 ± 0.90	127.-7 ± 1.07	125.32 ± 0.90	126.42 ± 0.90
FVC	2.11 ± .03	2.13 ± .02	2.01 ± .03	1.98 ± .03
FEV_1	1.72 ± .03	1.77 ± .02	1.61 ± .02	1.63 ± .03
FEV_1/FVC	0.81 ± .01	0.83 ± .01*	0.80 ± .01	0.82 ± .01
MMF	1.06 ± .02	1.06 ± .01	1.01 ± .01	0.99 ± .02

*($P < .1$)

The 1976-77 program was initiated in February of 1977. This four month period did not allow for a great deal of work, but it did serve to solve a lot of the problems within the experimental design, and problems between the research group, teachers, and pupils.

Questionnaire Comparisons Between Schools 1976-77

The questionnaire responses for the 4th and 5th grade children are summarized in Tables 9 and 10. All the summary data are presented as the number of responses followed by the percent of total responses.

The difference in sample size between Questionnaire I and II is that they were distributed as two parts and both parts were not always returned.

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Pulmonary Function Comparisons Between Schools 1977-78

Table 11 summarizes the adjusted baseline PFT for the 1977-78 year. All of the pulmonary function parameters measured were identical to the previous year. The same equipment was used and the procedures for coaching the students was again carefully standardized in all of the experiments. The pulmonary function data for the 1977-78 testing period are shown in Table 11. Student's t-test was used to compare mean values with the probability levels indicated.

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Table 9. Questionnaire Response Pediatric I 1976-77.
Number of responders followed by (%) of total.

	Betty Jane N=181			Seiberling N=156		
	Yes	No	NA	Yes	No	NA
2A. past 2 years has this child had any kind of heart trouble	2(1.1)	179(98.9)	0	0	155(99.4)	1(0.6)
B. past 2 years has child had high blood pressure	0	180(99.4)	1(0.6)	0	153(98.1)	3(1.9)
3. does child cough when he doesn't have a cold	28(15.5)	153(84.5)	0	31(19.9)	123(78.8)	2(1.3)
A. time this cough occurs						
early morning	13			15		
late morning	1			0		
afternoon	0			3		
evening	3			4		
during night	11			9		
no relation to time of day	8			9		
no answer	1					
B. any months in which child coughs on most days	9(32.1)	16(57.2)	3(10.7)	13(41.9)	17(54.9)	1(3.2)
number of months 1	0			1		
2	3(33.4)		1	0		
3	0		2	2(15.4)		
4	2(22.2)		3	3(23.2)		
5	0		4	3(23.2)		
6	1(11.1)		5	2(15.4)		
7	0		6	1(7.6)		
8	0		7	1(7.6)		
9	0					
10	0					
11	0					
12	2(22.2)					
no answer	1(11.1)			1(7.6)		
C. circle months in which cough is most severe Jan.	5			6		

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	Betty Jane N=181			Seiberling N=156		
	Yes	No	NA	Yes	No	NA
Feb.	5			6		
Mar.	5			6		
Apr.	5			4		
May	2			3		
June	1			3		
July	0			2		
Aug.	1			6		
Sep.	8			10		
Oct.	5			9		
Nov.	3			5		
Dec.	4			6		
no relation	3			2		
D. for how many years has he had a cough						
<2 yr.	9(32.1)			6(19.4)		
2-5 yr.	7(25.0)			8(25.8)		
>5 yr.	9(32.1)			14(45.1)		
no answer	3(10.8)			3(9.7)		
E. does weather affect cough	15(53.6)	11(39.3)	2(7.1)	23(74.2)		
F. does child cough more or less than two years ago						
more	4(14.4)			4(12.9)		
less	12(42.8)			11(35.5)		
no change	12(42.8)			16(51.6)		
B. past 2 years has he seen a doctor about cough	18(64.3)	19(35.7)	0	19(61.2)	10(32.3)	2(6.5)
4. does child bring up phlegm, sputum, or mucous or other fluids from chest without a cold	39(16.6)	148(81.8)	3(1.6)	29(18.6)	123(78.8)	4(2.6)
A. at what time of day does this occur						
early morning	19			16		
late morning	0			2		
afternoon	1			0		
evening	4			1		
during night	4			4		
no relation to time of day	6			9		

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	Betty Jane N=181			Seiberling N=156		
	Yes	No	NA	Yes	No	NA
no answer	0			1		
B. any months he brings up phlegm, sputum, or mucous from chest on most days	11(36.7)	18(60.0)	1(3.3)	11(37.9)	17(58.7)	1(3.4)
number of months 1	1(8.3)		1	0		
2	0		2	0		
3	3(25.0)		3	3(27.3)		
4	4(33.5)		4	2(18.2)		
5	0		5	4(36.3)		
6	1(8.3)		6	0		
7						
8	1(8.3)					
9						
10						
11						
12	1(8.3)					
no answer	1(8.3)			2(18.2)		
C. circle the months in which this is most severe						
Jan.	6			3		
Feb.	7			3		
Mar.	8			2		
Apr.	7			4		
May	4			4		
June.	0			1		
July	0			2		
Aug.	4			5		
Sep.	7			7		
Oct.	7			7		
Nov.	4			4		
Dec.	5			3		
no relation	5			3		
D. years he raised phlegm, sputum, or mucous from chest <2 yr.	9(30.0)			10(34.5)		
2-5 yr.	8(26.6)			6(20.7)		
>5 yr.	6(20.0)			9(31.0)		
no answer	7(23.2)			4(13.8)		
E. does weather affect this condition	17(56.6)	11(36.7)	2(6.7)	19(65.6)	9(31.0)	1(3.4)

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	Betty Jane N=181			Seiberling N=156		
	Yes	No	NA	Yes	No	NA
F. does child raise more or less phlegm, sputum, mucous from chest now than two years ago						
more	6(20.0)			5(17.2)		
less	6(20.0)			8(27.6)		
no change	14(46.7)			16(55.2)		
no answer	4(13.3)			0		
G. past 2 years has he seen doctor about this condition	11(36.7)	16(53.3)	3(10.0)	16(55.2)	13(44.8)	0
5. child's chest ever sound wheezy or whistling	33(18.2)	147(81.3)	1(0.5)	39(25.0)	112(71.8)	5(3.2)
A. does he get this with colds	30(90.0)	3(9.1)	0	34(87.1)	4(10.3)	1(2.6)
B. does he get this without colds	9(27.3)	20(60.6)	4(12.1)	18(46.2)	18(46.2)	3(7.6)
C. does he have wheezy sound on most days	2(6.1)	27(81.8)	4(12.1)	5(12.8)	31(79.5)	3(7.7)
6. has child had attacks of shortness of breath with wheezing	12(6.6)	166(91.7)	3(1.7)	24(15.4)	125(80.1)	7(4.5)
A. does he get this with colds	10(83.3)	2(16.7)	0	15(62.5)	7(29.2)	2(8.3)
B. does he get this without colds	4(33.3)	7(58.4)	1(8.3)	14(58.4)	8(33.3)	2(8.3)
C. past year number attacks of shortness of breath with wheezing did child have						
none	2(16.7)			7(29.2)		
few	7(58.3)			10(41.6)		
several	1(8.3)			4(16.7)		
many	2(16.7)			2(8.3)		
no answer	0			1(4.2)		
D. age of child at first attack						
0-3 mo.	3(25.1)		0-3 mo.	4(16.7)		
4-6 mo.	1(8.3)		4-6 mo.	2(8.3)		

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	Betty Jane N=181			Seiberling N=156		
	Yes	No	NA	Yes	No	NA
4D. (continued)						
1 yr.	1(8.3)		1 yr.	3(12.5)		
2	2(16.7)		2	2(8.3)		
3	0		3	0		
4	0		4	2(8.3)		
5	2(16.7)		5	3(12.5)		
6	0		6	1(4.2)		
7	0		7	1(4.2)		
8	0		8	0		
9	1(8.3)		9	1(4.2)		
10	1(8.3)		10	3(12.5)		
11	0		11	0		
12	0		12	0		
no answer	1(8.3)		no answer	2(8.3)		
E. age of child when last attack						
1	0		1	0		
2	0		2	0		
3	0		3	0		
4	0		4	0		
5	1(8.3)		5	2(8.3)		
6	1(8.3)		6	2(8.3)		
7	0		7	1(4.2)		
8	0		8	1(4.2)		
9	2(16.7)		9	4(16.7)		
10	1(8.3)		10	9(37.5)		
11	5(41.8)		11	2(8.3)		
12	1(8.3)		12	0		
no answer	1(8.3)		no answer	3(12.5)		

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Table 10. Questionnaire Response Pediatric II 1976-77. Number of responders followed by (%) of total.

	Betty Jane N=185			Seiberling N=164		
	Yes	No	NA	Yes	No	NA
2. shortness of breath while walking	7(3.8)	178(96.2)	0	9(5.5)	154(93.9)	1(0.6)
3. shortness of breath while playing	14(7.6)	179(91.9)	1(0.5)	19(11.6)	144(87.8)	1(0.6)
4. stop to catch breath while walking	5(2.7)	159(81.1)	1(0.5)	10(6.1)	153(93.3)	1(0.6)
5. stop to catch breath while playing	30(16.2)	150(81.1)	5(2.7)	45(27.4)	117(71.4)	2(1.2)
6. shortness of breath walking with child same age	2(1.1)	183(98.9)	0	6(3.7)	156(95.1)	2(1.2)
7. stop for breath walking own pace on level ground	1(0.5)	183(99.0)	1(0.5)	1(0.6)	161(98.2)	2(1.2)
8. shortness of breath, normal play, more now than 2 years ago	8(4.3)	176(95.2)	1(0.5)	10(6.1)	153(93.3)	1(0.6)
9. during past two years, has this child seen a doctor because of shortness of breath	2(1.1)	182(98.4)	1(0.5)	11(6.7)	152(92.7)	1(0.6)

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		Betty Jane N=185			Seiberling N=164		
		Yes	No	NA	Yes	No	NA
10.	past 2 years, how often was this child unable to do his activities because of illness such as chest cold, etc.						
	never	116(62.8)			107(65.3)		
	1-illness	43(23.2)			22(13.4)		
	2-5 illness	16(8.6)			23(14.0)		
	6 or more	4(2.2)			5(3.0)		
	no answer	6(3.2)			7(4.3)		
11.	past years, how many days unable usual activities because of such illnesses						
	0	133(72.0)		0	120(73.2)		
	1	3(1.6)		1	3(1.8)		
	2	13(7.0)		2	9(5.5)		
	3	10(5.4)		3	7(4.3)		
	4	5(2.7)		4	7(4.3)		
	5	5(2.7)		5	7(4.3)		
	6	2(1.1)		6	2(1.2)		
	7	3(1.6)		7	1(0.6)		
	8	1(0.5)		8	2(1.2)		
	9	2(1.1)		9	0		
	10	3(1.6)		10	2(1.2)		
	11	0		11	0		
	12	2(1.1)		12	0		
	13	0		13	0		
	14	2(1.1)		14	1(0.6)		
	21	1(0.5)		15	1(0.6)		
				20	1(0.6)		
				30	1(0.6)		
12.	past year, has child seen a doctor for						
A.	emphysema	0	175(94.6)	10(5.4)	1(0.6)	150(91.5)	13(7.9)
B.	chronic bronchitis	7(3.8)	170(91.9)	8(4.3)	6(3.7)	146(89.0)	12(7.3)
C.	bronchiectasis	2(1.1)	170(91.9)	13(7.0)	3(1.8)	147(89.7)	14(8.5)
D.	asthma	3(1.6)	170(91.9)	12(6.5)	9(5.5)	145(88.4)	10(6.1)
E.	sinus trouble	28(15.1)	148(80.0)	9(4.9)	28(17.1)	130(79.2)	6(3.7)
F.	pneumonia	4(2.2)	172(92.9)	9(4.9)	3(1.8)	149(90.0)	12(7.3)
G.	acute bronchitis	8(4.3)	167(90.3)	10(5.4)	1(0.6)	148(90.3)	15(9.1)

	Betty Jane N=185			Seiberling N=164		
	Yes	No	NA	Yes	No	NA
H. asthmatic bronchitis	3(1.6)	172(93.0)	10(5.4)	5(3.1)	144(87.8)	15(9.1)
I. bronchiolitis	6(3.2)	165(89.2)	14(7.6)	4(2.4)	141(86.0)	19(11.6)
J. croup	7(3.8)	166(89.7)	12(6.5)	3(1.8)	146(89.1)	15(9.1)
K. whooping cough	1(0.5)	172(93.0)	12(6.5)	1(0.6)	149(90.9)	14(8.5)
L. eczema	1(0.5)	172(93.0)	12(6.5)	4(2.4)	143(87.2)	17(10.4)
M. other respiratory diseases	3(1.6)	171(92.5)	11(5.9)	7(4.3)	144(87.8)	13(7.9)
13. hay fever or other condition causing runny and stuffy nose apart from colds	64(34.6)	116(62.7)	5(2.7)	52(31.7)	108(65.9)	4(2.4)
A. age of child when this first noticed			0-3 mo.	3(5.8)		
1	8(12.5)		1 yr.	5(9.6)		
2	5(7.8)		2	6(11.5)		
3	7(10.9)		3	4(7.7)		
4	4(6.3)		4	4(7.7)		
5	9(14.1)		5	7(13.6)		
6	3(4.7)		6	6(11.5)		
7	7(10.9)		7	3(5.8)		
8	6(9.4)		8	4(7.7)		
9	13(20.3)		9	6(11.5)		
10	0		10	1(1.9)		
11	0		11	2(3.8)		
12	0		12	0		
no answer	2(3.1)		no answer	1(1.9)		
B. age of child when last had this condition 1	0			0		
2	0			0		
3	2(3.1)			0		
4	0			1(1.9)		
5	2(3.1)			2(3.8)		
6	0			0		
7	2(3.1)			2(3.8)		
8	3(4.7)			0		
9	11(17.2)			17(32.8)		
10	27(42.1)			17(32.8)		
11	12(18.8)			10(19.2)		
12	4(6.3)			2(3.8)		
no answer	1(1.6)			1(1.9)		
C. has doctor said this condition due to allergy	39(60.9)	25(39.1)	0	31(59.6)	29(38.5)	1(1.9)

	Betty Jane N=185			Seiberling N=164		
	Yes	No	NA	Yes	No	NA
14. past year, allergic reaction due to food or medicine	13(7.0)	171(92.5)	1(0.5)	9(5.5)	150(91.5)	5(3.0)
15. past year has child received allergy shots	9(4.9)	174(94.0)	2(1.1)	11(6.7)	147(89.6)	6(3.7)
16. troubled by itching, or burning of the eyes	44(23.8)	140(75.7)	1(0.5)	38(23.2)	121(73.8)	5(3.0)
A. circle months symptoms most severe Jan.	3			3		
Feb.	3			3		
Mar.	3			2		
Apr.	4			5		
May	5			4		
June	11			4		
July	15			7		
Aug.	20			14		
Sep.	15			15		
Oct.	7			9		
Nov.	2			3		
Dec.	3			3		
no relation	13			16		
no answer	2			1		
B. have this most days for 1 month of year	25(56.8)	16(36.4)	3(6.8)	16(42.1)	19(50.0)	3(7.9)
C. do you think eye problem is due to allergy	28(63.6)	16(36.4)	0	24(63.2)	11(28.9)	3(7.9)
D. has doctor ever said it was due to allergy	21(47.7)	22(50.0)	1(2.3)	16(42.1)	21(55.3)	1(2.6)
17. past year has child had chest x-ray	17(9.2)	168(90.8)	0	15(9.1)	142(86.6)	7(4.3)
18. past year, has child been hospitalized for heart or lung problem	0	185(100)	0	0	158(96.3)	6(3.7)

	Betty Jane N=185			Seiberling N=164		
	Yes	No	NA	Yes	No	NA
19. has this child ever had heart or lung surgery	0	185(100)	0	0	157(95.7)	7(4.3)

Table 11. Comparative adjusted mean baseline values for all males and females in Seiberling and Betty Jane schools 1977-78 ($\bar{x} \pm SE$).

	Males		Females	
	Seib N=74	B.J. N=94	Seib. N=64	B.J. N=59
Ht (cm)	144.10 ± 0.90	145.90 ± 0.90	143.68 ± 0.80	146.60 ± 1.13
Wt (Kg)	40.20 ± 1.47	39.60 ± 1.17	39.72 ± 1.1	40.07 ± 1.40
Age (months)	134.80 ± 1.17	135.20 ± 0.80	132.50 ± 0.9	135.20 ± 1.00
FVC	2.61 ± .03	2.49 ± .02	2.37 ± .04	2.33 ± .03
FEV	2.09 ± .03	2.03 ± .02	1.94 ± .04	1.96 ± .03
FEV_1/FVC	0.80 ± .01	0.81 ± 0.01*	0.81 ± .01	0.84 ± .01**
MMF	2.26 ± .06	2.22 ± .06	2.50 ± .06	2.40 ± .07

*(P < .1) **(P < .025)

The only consistent differences in these data are the values for FEV_1/FVC; they are higher in the Betty Jane school. The value FEV_1/FVC has always been used as a standard calculation in PFT and Knudson (43) has indicated that it is as good as flow values at 50% of FVC and FEV_1 in detecting ventilatory abnormalities.

Questionnaire Comparisons Between Schools 1977-78

The questionnaire responses for the 5th and 6th grade children are summarized in Table 12 and 13. The data consists of number of responders followed by the percent of total responses. These data represent responses from only those children who participated in the 1976-77 part of the study. There were some new students recruited into the program during the second year of the study. The questionnaire responses of the new participants

Table 12. Questionnaire Response Pediatric I 1977-78.
Number of responders followed by (%) of total.

	Betty Jane N=108			Seiberling N=97		
	Yes	No	NA	Yes	No	NA
2A. past year, heart trouble	0	108(100)	0	0	97(100)	0
B. high blood pressure	1(0.9)	106(98.2)	1(0.9)	0	95(97.9)	2(2.1)
3. Cough when no cold	20(18.5)	88(81.5)	0	19(19.6)	78(80.4)	0
A. time of day cough occurs						
1. morning after rising	12			7		
2. later in morning	0			0		
3. afternoon	0			2		
4. evening	2			7		
5. during night	6			6		
6. no relation	3			6		
B. any months child coughs on most days	12(60.0)	7(35.0)	1(5.0)	6(31.6)	13(68.4)	
If yes, specify number of months/ year 1	1		1	0		
2	4			2		
3	3			2		
4	1			0		
5	1			0		
6	0			0		
7	0			0		
8	0			2		
9	0			0		
10	0			0		
11	0			0		
12	1			0		
C. years child had cough <2	4(20.0)		2(10.0)	4(21.0)		2(10.5)
2-5	8(40.0)			3(15.8)		
>5	6(30.0)			10(52.7)		
D. weather affect cough	17(85.0)	3(15.0)	0	12(63.1)	7(36.9)	0
E. months most severe Jan.	3			5		
Feb.	3			5		
Mar.	2			4		
Apr.	6			3		
May	6			2		

	Betty Jane N=108			Seiberling N=97		
	Yes	No	NA	Yes	No	NA
3E. (continued)						
June	3			2		
July	2			2		
Aug.	7			4		
Sep.	10			6		
Oct.	6			4		
Nov.	3			3		
Dec.	2			4		
No relation to time of year	5			6		
F. cough more or less now than year ago						
more	5(25.0)			0		6(31.1)
less	3(15.0)			8(42.1)		
no change	12(60.0)			5(26.3)		
G. past year, seen doctor for cough	6(30.0)	14(70.0)	0	4(21.0)	13(68.5)	2(10.5)
4. bring flem, sputum, mucous or fluid from chest	14(13.0)			13(13.4)	83(85.6)	1(1.0)
A. time of day this occurs						
1. morn. after rising	9			8		
2. later in morning	0			0		
3. afternoon	0			1		
4. evening	3			0		
5. during night	2			1		
6. no relation	1			5		
B. any months occurs on most days	7(50.0)	6(42.9)	1(7.1)	5(38.5)	8(61.5)	0
If yes, specify number of months/ year 1	0			0		
2	3(42.8)			2(40.0)		
3	1(14.3)			1(20.0)		
4	1(14.3)			0		
5	0			0		
6	2(28.6)			0		
7	0			0		
8	0			0		
9	0			0		
10	0			0		
11	0			0		
12	0			1(20.0)		

	Betty Jane N=108			Seiberling N=97		
	Yes	No	NA	Yes	No	NA
C. months most severe						
Jan.	1			2		
Feb.	1			2		
Mar.	1			2		
Apr.	2			2		
May	4			2		
June	2			0		
July	2			0		
Aug.	7			4		
Sep.	8			4		
Oct.	4			3		
Nov.	2			2		
Dec.	1			3		
No relation	2			5		
D. years raised phlegm, sputum, mucous from chest <2	3(21.4)		1(7.1)	7(53.8)		
2-5	6(42.9)			2(15.4)		
>5	4(28.6)			4(30.8)		
E. weather affect condition	13(92.9)	0	1(7.1)	8(61.5)	4(30.8)	1(7.7)
F. past year raise more or less phlegm, from chest, than previously						
more	3(21.4)			0		
less	2(14.3)			8(61.5)		
no change	9(64.3)			5(38.5)		
G. past year, sputum raised each day						
none	1(7.1)		1(7.1)	1(7.7)		
<1 tsp.	10(71.5)			8(61.5)		
1 tsp.-1/4 c.	2(14.3)			4(30.8)		
>1/4 c.	0			0		
H. past year, seen doctor about condition	6(42.9)	7(50.0)	1(7.1)	6(46.2)	7(53.8)	0
I. past year, how often was child's sputum yellow or green color						
never	6(42.9)			5(38.4)		1(7.7)
rarely	3(21.4)			3(23.1)		
occasionally	3(21.4)			1(7.7)		
often	2(14.3)			2(15.4)		
very often	0			1(7.7)		

	Betty Jane N=108			Seiberling N=97		
	Yes	No	NA	Yes	No	NA
5. child's chest sound wheezy or whistling	17(15.7)	91(84.3)	0	26(26.8)	71(73.2)	0
A. get this with colds	16(94.1)	1(5.9)	0	21(80.8)	5(19.2)	0
B. get this without cold	9(52.8)	8(47.2)	0	13(50.0)	13(50.0)	0
C. runny or stuffy nose with wheezy or whistling chest	14(82.4)	3(17.6)	0	23(88.5)	3(11.5)	0
D. wheezy sound on most days	4(23.5)	13(76.5)		0	26(100)	0
E. past year wheezing or whistling						
improved	5(29.4)		1(5.9)	13(50.0)		1(3.8)
worsened	0			0		
stayed same	11(64.7)			12(46.2)		
6. attacks of shortness of breath with wheezing	9(8.3)	97(89.8)	2(1.9)	14(14.4)	83(85.6)	0
A. get this with colds	7(77.8)	1(11.1)	1(11.1)	9(64.3)	4(28.6)	1(7.1)
B. get this without colds	3(33.3)	5(55.6)	1(11.1)	8(57.1)	6(42.9)	0
C. past year number of attacks of shortness of breath with wheezing						
none	1(11.1)		1(11.1)	4(28.7)		1(7.1)
1-3	4(44.5)			7(50.0)		
4-10	2(22.2)			1(7.1)		
>11	1(11.1)			1(7.1)		
D. past year, symptoms						
improved	0		1(11.1)	8(57.1)		
worsened	1(11.1)			0		
stayed same	7(77.8)			6(42.9)		
E. past year, 2 weeks no breathing problems even with exercise	5(55.6)	4(44.4)		8(57.2)	5(35.7)	1(7.1)
F. age at first attack						
0-3 mo.	2(22.2)		2(22.3)	2(14.3)		2(14.3)
4-6				1(17.1)		
7-9				0		
1 yr.	0			0		
2	1(11.1)			6(42.9)		
3	1(11.1)			0		
4	1(11.1)			1(7.1)		
5	0			0		

		Betty Jane N=108			Seiberling N=97		
		Yes	No	NA	Yes	No	NA
	6	1(11.1)			0		
	7	0			1(7.1)		
	8	0			0		
	9	1(11.1)			1(7.1)		
G. age child last attack	4-6 mo.				1(7.1)		3(21.4)
	7-9				1(7.1)		
	4 yr.				1(7.1)		
	5						
	6						
	7						
	8	1(11.1)		2(22.3)	0		
	9	0			2(14.5)		
	10	2(22.2)			3(21.4)		
	11	2(22.2)			3(21.4)		
	12	2(22.2)			0		
7. anyone smoke in house		69(63.9)	35(32.4)	4(3.7)	67(69.0)	28(28.9)	2(2.1)
A. number cigarettes							
	4	1(1.5)		3(4.3)	1	1(1.5)	3(4.3)
	5	2(2.9)			2	1(1.5)	
	6	3(4.3)			4	1(1.5)	
	8	1(1.5)			5	2(2.9)	
	10	3(4.3)			10	7(10.1)	
	13	1(1.5)			15	1(1.5)	
	15	1(1.5)			20	21(30.4)	
	18	1(1.5)			21	1(1.5)	
	20	23(33.3)			23	2(2.9)	
	23	1(1.5)			25	2(2.9)	
	25	1(1.5)			30	8(11.6)	
	30	5(7.2)			40	10(14.5)	
	35	1(1.5)			50	1(1.5)	
	40	15(21.7)			60	1(1.5)	
	60	2(2.9)					
	102	1(1.4)					
B. number cigars					3	1(1.4)	
	1	2(2.9)			4	1(1.4)	
	20	1(1.4)			2	2(2.9)	
C. pipes	5	1(1.4)			5	1(1.4)	
					10	1(1.4)	
					12	1(1.4)	

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Table 13. Questionnaire Response Pediatric II 1977-78. Response in % of Total.

	Betty Jane N=108			Seiberling N=97		
	Yes	No	NA	Yes	No	NA
2. shortness of breath while walking	3(27.8)	105(97.2)	0	5(5.2)	92(94.8)	0
3. shortness of breath while playing	9(8.3)	99(91.7)	0	10(10.3)	87(89.7)	
4. stop catch breath while walking	3(2.8)	104(96.2)	0	6(6.2)	91(93.8)	0
5. stop catch breath while playing	13(12.0)	94(87.0)	1(1.0)	14(14.4)	82(84.6)	1(1.0)
6. short of breath on level ground or on slight hill	7(6.5)	99(91.7)	2(1.8)	11(11.4)	85(87.6)	1(1.0)
7. short of breath with children same age on level ground	2(1.9)	106(98.1)	0	3(3.1)	94(96.9)	0
8. catch breath, own pace on level ground	1(0.9)	107(99.1)	0	2(2.1)	95(97.9)	0
9. short of breath normal play, more often now than 1 year ago	3(2.8)	105(97.2)	0	2(2.1)	95(97.9)	0
10. past year, seen doctor because short of breath	2(1.9)	106(98.1)	0	3(3.1)	94(96.9)	0
11. past year, unable to do activities because of chest colds, bronchitis or pneumonia						
never	85(78.7)		1(0.9)	67(69.0)	1(1.0)	
1-illness	18(16.7)			17(17.6)		
2-4 illnesses	3(2.8)			12(12.4)		
6 or more	1(0.9)			0		

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	Betty Jane N=108			Seiberling N=97		
	Yes	No	NA	Yes	No	NA
12. past year, number days unable to do activities because of such illness						
0	86(79.5)			67(69.1)		
1	3(2.8)			2(2.1)		
2	4(3.7)			7(7.2)		
3	4(3.7)			4(4.1)		
4	2(1.9)			4(4.1)		
5	3(2.8)			3(3.1)		
6	0			2(2.1)		
7	1(0.9)			3(3.1)		
8	0			0		
9	0			0		
10	3(2.8)			3(3.1)		
11	0			0		
12	0			1(1.0)		
13	0			0		
14	2(1.9)			0		
15				1(1.0)		
13. past year, seen doctor for:						
A. bronchiectasis	3(2.9)	98(90.7)	7(6.5)	5(5.1)	86(88.7)	6(6.2)
B. sinus trouble	18(16.7)	88(81.5)	2(1.8)	18(18	75(77.3)	4(4.1)
C. pneumonia	1(0.9)	100(92.6)	7(6.5)	1(1.0)	85(87.6)	11(11.4)
D. acute bronchitis	3(2.8)	96(88.9)	9(8.3)	0	89(91.7)	8(8.3)
E. asthmatic bronchitis	3(2.8)	98(90.7)	7(6.5)	6(6.2)	83(85.6)	8(8.2)
F. bronchiolitis	4(3.7)	96(88.9)	8(7.4)	0	89(91.8)	8(8.2)
G. croup	1(0.9)	97(89.8)	10(9.3)	4(4.1)	81(83.5)	12(12.4)
H. other respiratory disease	8(7.4)	90(83.3)	10(9.3)	6(6.2)	79(81.4)	12(12.4)
14. seen doctor for chronic bronchitis	5(4.6)	99(91.7)	4(3.7)	7(7.2)	88(90.4)	2(2.1)
A. past year, symptoms						
improved	3(60.0)			6(85.7)		
worsened	0			0		
stayed same	2(40.0)			1(14.3)		
B. treatment for medication for chronic bronchitis	3(60.0)	2(40.0)	0	5(71.4)	1(14.3)	1(14.3)

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	Betty Jane N=108			Seiberling N=97		
	Yes	No	NA	Yes	No	NA
15. seen doctor for asthma	3(2.8)	103(95.3)	2(1.9)	12(12.4)	85(87.6)	0
A. past year, symptoms						
improved	1(33.3)			9(75.0)		
worsened	0			0		
stayed same	2(66.7)			3(25.0)		
B. past year, 2 weeks without breathing problem, even with exercise	1(33.3)	2(66.7)	0	9(75.0)	1(8.3)	2(16.7)
C. child's attacks relieved by treatment						
within minutes	0			0		
within hours	2(66.7)		1(33.3)	5(41.7)		
within days				3(25.0)		
not relieved				0		
no treatment				4(33.3)		
16. hay fever or other condition making nose runny, stuffy apart from colds	43(39.8)	64(59.3)	1(0.9)	32(33.0)	64(66.0)	1(1.0)
A. age first noticed						
0-3 mo.	4(9.3)		1(2.3)	4(12.5)		2(6.3)
4-6				1(3.1)		
7-9				1(3.1)		
1 yr.	2(4.7)			0		
2	4(9.3)			2(6.2)		
3	1(2.3)			2(6.2)		
4	4(9.3)			6(18.8)		
5	5(11.6)			3(9.4)		
6	4(9.3)			2(6.3)		
7	3(7.0)			1(3.1)		
8	3(7.0)			3(9.4)		
9	6(13.9)			2(6.2)		
10	3(7.0)			3(9.4)		
11	3(7.0)			0		
12	0			0		
B. age last had condition						
1	0		1(2.3)	0		2(6.3)
2	1(2.3)			1(3.1)		
3	0			0		
4	0			0		

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	Betty Jane N=108			Seiberling N=97		
	Yes	No	NA	Yes	No	NA
5	0			0		
6	0			0		
7	2(4.7)			0		
8	0			0		
9	2(4.7)			3(9.4)		
10	17(39.5)			17(53.1)		
11	18(41.9)			8(25.0)		
12	2(4.7)			1(3.1)		
17. past year, allergic reaction to food, medicine	6(5.5)	100(92.6)	2(1.9)	6(6.2)	91(93.8)	0
18. past year, allergy shots	5(4.6)	101(93.5)	2(1.9)	5(5.2)	92(94.8)	0
19. past year troubled by redness, itching, burning of eyes	35(32.4)	71(65.7)	2(1.9)	27(27.8)	69(71.2)	1(1.0)
A. months symptoms most severe Jan.	0			0		
Feb.	0			0		
Mar.	0			1		
Apr.	4			3		
May	6			4		
June	9			4		
July	5			5		
Aug.	12			14		
Sep.	12			12		
Oct.	8			3		
Nov.	1			0		
Dec.	1			0		
No relation	13			9		
B. have symptoms most days, one month	17(48.6)	17(48.6)	1(2.8)	12(44.4)	14(51.9)	1(3.7)
C. think problem due to allergy	22(62.9)	13(37.1)	0	22(81.5)	5(18.5)	0
D. doctor said due to allergy	12(34.3)	23(65.7)	0	16(59.3)	11(40.7)	0
20. past year, child had x-ray	5(4.6)	100(92.6)	3(2.8)	8(8.2)	89(91.8)	0
21. past year, hospitalized heart and lung problem	0	104(96.3)	4(3.7)	0	94(96.9)	3(3.1)
22. past year, other serious illness	6(5.6)	99(91.6)	3(2.8)	6(6.2)	88(90.7)	3(3.1)

were compiled with the first year responders (1976-77) but their pulmonary function data were compiled with the 1977-78 data.

The difference for selected questionnaire responses between the two schools were compared using the relative risk ratio (RRR) according to Mantel and Haenzel (44). These results are shown in Table 14 for the categories where there are significant differences. Questionnaire items not listed were not significantly different. There were particularly large differences between the two schools for shortness of breath and wheezing chest. The test of X^2 was used to determine levels of significance.

Additionally, the questionnaires were used to devise a set of syndromes which were examined according to male and female as follows:

1. Cough Phlem Syndrome (CPS)

   Grade 2 = a positive response to question 3 and 4

   Grade 1 = a positive response to question 3 or 4

   Grade 0 = a negative response to question 3 and 4

2. Shortness of Breath Syndrome (SOB)

   Grade 4 = a positive response to question 4

   Grade 3 = a positive response to question 5

   Grade 2 = a positive response to question 2

   Grade 1 = a positive response to question 3

   Grade 0 = negative response to all

3. Wheezing Syndrome (WH)

   Grade 3 = a positive response to question 5d

   Grade 2 = a positive response to question 5b

   Grade 1 = a positive response to question 5a

   Grade 0 = negative response to question 5

Table 14. Relative Risk Ratios (RRR) and Levels of Probability for Pediatric Questionnaire Responses in Akron, OH (RRR = $\frac{\text{RR Seib}}{\text{RR BJ}}$)

	I #3 Cough without cold	I #5 Chest wheezy and whistling	I #6 Shortness of breath with wheezing	II #3 Short of breath while playing	II #4 Catch breath while walking	II #5 Catch breath while playing	II #9 Past two years seen a doctor for shortness of breath
1976-77	1.28 NS	1.37 (P = .08)	2.32 (P = .008)	1.53 NS	2.26 (P = .09)	1.69 (P = .008)	6.21 (P = .006)
1977-78	1.06 NS	1.70 (P = .04)	1.73 (P = .1)	1.23 NS	2.23 NS	1.20 NS	1.67 NS

4. Wheezing dyspnea and Dx asthma

All cases a positve response to question 15.

Grade 4 = a positive response to question 6C, many (11 or more)

Grade 3 = a positive response to question 6C, several (4-10)

Grade 2 = a positive response to question 6C, a few (1-3)

Grade 1 = a positive response to question 6C, none

Grade 0 = no to question 6

5. Wheezing dyspnea only - same as #4 above but without Dx asthma

Table 15 shows the RRR for the above categories with the levels of significance indicated. Probability values were obtained by taking the square root of X^2 and using standard normal tables.

Pulmonary Function Comparisons Within Schools and Acute Respiratory Illness (ARI)

The daily symptom sheets were tallied on a weekly basis and expressed as a percent of these students reporting a particular symptom, Figures 6 and 7.

In each school, all of the data were calculated and tallied independently by the investigators. This point is made because there is a striking similarity between the occurrence of high and low reported symptoms at the school.

In order to assess the daily affects of TSP, SO_2, and NO_2, each pollutant was correlated with the individual daily symptom of the students. The data were arranged in a lag matrix where TSP, NO_2, and SO_2 were held constant and the individual symptoms were displaced or lagged one day at a time to 9 days. Correlation coefficients and levels of probability were calculated for each lag day. This technique makes it possible to

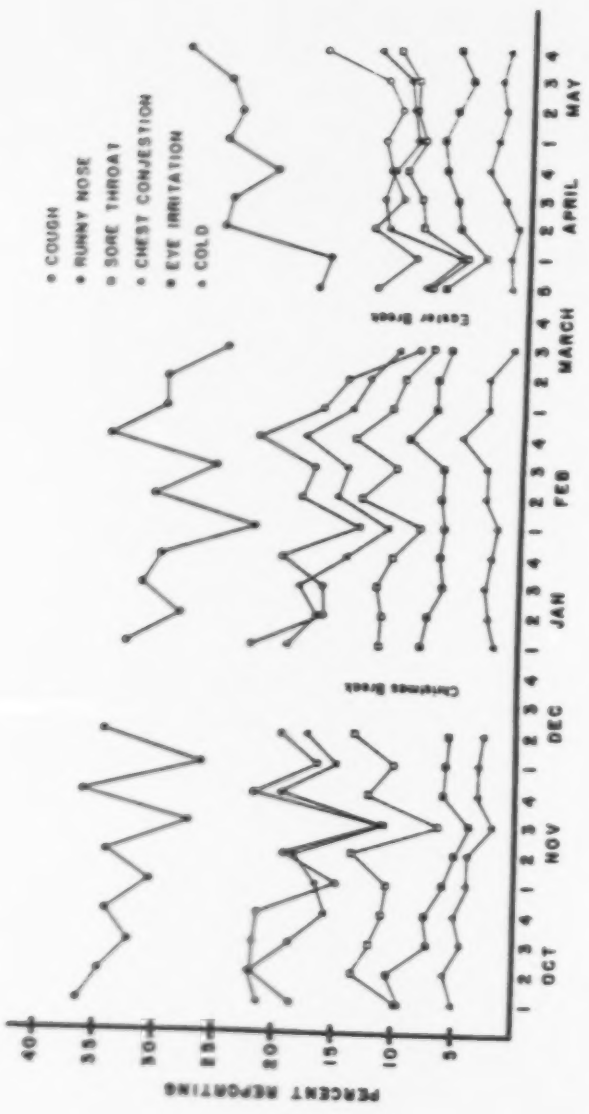

Figure 6 - Weekly symptoms reported by
5th and 6th grade children
at Seiberling School 1977-78.

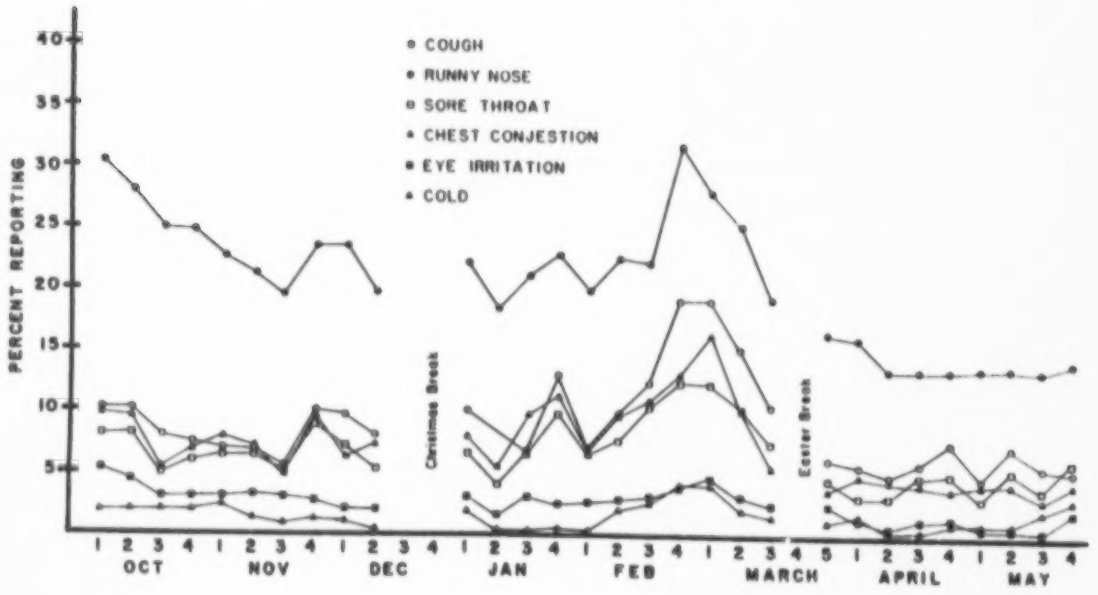

Figure 7 - Weekly symptoms reported by 5th and 6th grade children at Betty Jane School 1977-78.

Table 15. Relative Risk Ratios* and Levels of Significance of Syndromes in Akron, OH.

	CPS (Grade 1^+)	SOB (Grade 3^+)	Wheeze (Grade 2^+)	Wheezing dyspnea (Grade 1^+)	Wheezing dyspnea & Dx asthma
1976-77	1.17 (ns)	1.29 (P = .103)	2.39 (P = .02)	2.00 (P = .02)	No data
1977-78	1.16 (ns)	1.49 (P = .2)	1.45 (P = .2)	2.25 (P = .04)	**

*the RRR's were set up as $\frac{\text{RR Seiberling}}{\text{RR Betty Jane}}$ on the assumption that the elevated SO_2 and NO_2 levels would have more effect on students residing in the Seiberling school area.

**8 responders at Seiberling, none at Betty Jane.

determine if the aerometric data have a residual or delayed effect on the daily symptoms and are affecting the children several days after a spike or a high daily value.

Since there were some missing aerometric data the existing aerometric data and meterologic data were entered into a multiple correlation matrix and missing TSP, SO_2, and NO_2 values were estimated (45). This enables us to use all of the daily symptom data and affect better statistical inferences.

From the data reported in Tables 16 and 17 it appears that the symptoms cough, sore throat, and runny nose are most affected by SO_2 two and three days after a given SO_2 value. The same symptoms are most affected by NO_2 from days zero (0) to day five (5). TSP did not seem to have any constant effect on any of the symptoms.

Table 16. Summary of lag correlations for SO_2. Values are correlation coefficients (r) and levels of probability (P).

	Days	Cough	Sr. Throat	Runny nose	Chest cong.	Eye irr.	Cold
SO_2	0	.20(.03)	.12(.1)	.16(.95)	.03(.4)	.03(.4)	-.005(.5)
	1	.09(.16)	.06(.27)	.13(.10)	.05(.3)	.002(.5)	.08(.2)
	2	.2(.01)	.18(.04)	.14(.08)	-.07(.2)	-.01(.4)	.12(.1)
	3	.2(.03)	.18(.03)	.18(.03)	-.1(.2)	.02(.4)	.14(.07)
	4	.12(.1)	.06(.3)	.08(.2)	.09(.2)	-.01(.45)	.05(.3)
	5	.12(.1)	.03(.3)	.15(.07)	-.03(.3)	.01(.4)	.09(.18)
	6	.09(.18)	.02(.4)	.05(.28)	-.002(.5)	-.08(.2)	.02(.4)
	7	.03(.4)	.003(.5)	.033(.4)	.04(.3)	-.02(.4)	.04(.3)
	8	.03(.3)	.04(.3)	.08(.2)	-.01(.4)	-.08(.2)	.04(.3)
	9	.04(.3)	.05(.3)	.03(.4)	-.01(.45)	-.02(.4)	.04(.3)

Table 17. Summary of lag correlation for NO_2. Values are correlation coefficients (r) and levels of probability (P).

	Days	Cough	Sr. Throat	Runny nose	Chest cong.	Eye irr.	Cold
NO_2	0	.3(.001)	.2(.02	.27(.003)	.05(.3)	.19(.03)	.19(.03)
	1	.24(.006)	.17(.05)	.26(.004)	.18(.04)	.26(.005)	.17(.14)
	2	.28(.002)	.16(.05)	.14(.08)	-.03(.35)	.12(.1)	.19(.02)
	3	.29(.002	.17(.04)	.19(.02)	.1(.14)	.19(.02)	.19(.03)
	4	.19(.03)	.02(.4)	.02(.4)	-.02(.4)	.03(.4)	.11(.13)
	5	.15(.06)	.07(.25)	.17(.04)	.06(.25)	.05(.3)	.12(.1)
	6	.07(.2)	.007(.5)	.1(.15)	-.07(.2)	.03(.4)	-.006(.47)
	7	.07(.2)	-.13(.09)	.09(.17)	.05(.3)	.07(.2)	.06(.3)
	8	.09(.2)	.03(.4)	.09(.16)	-.02(.4)	.02(.4)	.08(.2)
	9	.02(.4)	.07(.2)	.01(.4)	.01(.4)	.01(.45)	-.01(.4)

For any given symptom there is about double the number reported at Seiberling than at Betty Jane. Initially, it was thought that absenteeism could partially explain the increased incidence of reported symptoms at the Seiberling school. If there was more absenteeism at the Betty Jane school then a possible explanation could be that at the Seiberling school the children were coming to school despite having ARI symptoms where at Betty Jane school they were remaining home. There are a few more absentee peaks at the Seiberling school but the peaks do not correspond to peaks in symptoms. Additionally, when absenteeism was low, the symptoms remained high. Admittedly, a certain percentage of the symptoms reported could be due to a few more children coming to school

with ARI's but not all of the symptoms can be explained by this factor. Absenteeism for both schools is shown in Figure 8.

The pulmonary function testing that was carried out during the symptomatic phases of ARI at the Betty Jane school are summarized in Tables 18 and 19. These adjusted means indicate that both symptomatic A and B FVC and FEV_1 are significantly reduced when compared to baseline values.

Table 18. Symptomatic A conditions for children reporting at Betty Jane school ($\bar{x} \pm SE$).

	Baseline	ARI	Δ	N	P
FVC	2.658 ± .033	2.532 ± .032	.126 ± .018	46	<.01
FEV_1	2.164 ± .031	2.045 ± .031	.119 ± .022	46	<.01
FEV_1/FVC	0.815 ± .008	0.809 ± .010	.006 ± .005	46	ns
MMF	2.391 ± 0.88	2.318 ± .093	.073 ± .045	46	ns

Table 19. Symptomatic B conditions for children reporting at Betty Jane school ($\bar{x} \pm SE$).

	Baseline	ARI	Δ	N	P
FVC	2.694 ± .039	2.548 ± .039	.146 ± .024	33	<.01
FEV_1	2.174 ± .037	2.075 ± .041	.099 ± .020	33	<.01
FEV_1/FVC	0.810 ± .010	0.813 ± .011	.003 ± .005	33	ns
MMF	2.338 ± .108	2.267 ± .110	.070 ± .047	33	ns

The magnitude of the reduction is greater for FVC than for FEV_1 thus accounting for the non-significant values for FEV_1/FVC. The difference in the sample size between symptomatic A and symptomatic B occurred because it was not always possible to test each child twice

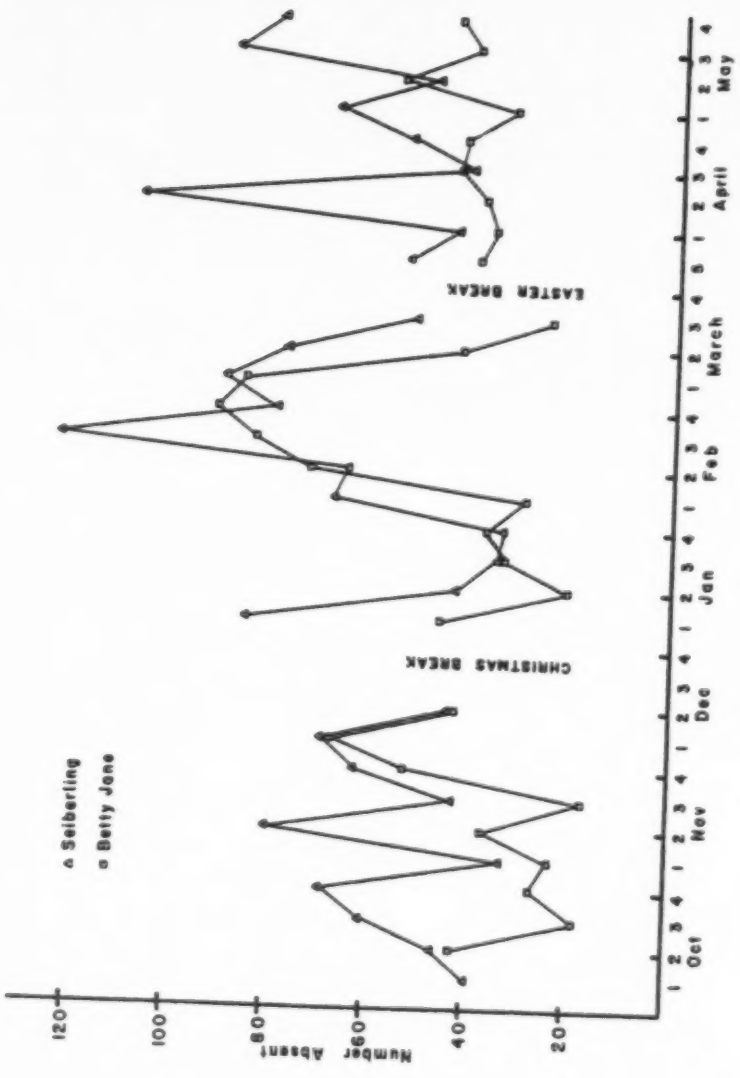

Figure 8 - Absenteeism at Selberling
and Betty Jane School 1977-78.

during the symptomatic phase of an ARI. Such findings of reduced lung functions during an ARI are not new and have recently been shown again by Collier (46).

The pulmonary function tests that were carried out during symptomatic phase of an ARI at the Seiberling school are summarized in Tables 20 and 21. These adjusted means are somewhat different than the Betty Jane data (Table 18 and 19). The differences in FVC are similar to those of the Betty Jane students but the FEV_1 differences are greater given rise to a significant difference in the values for FEV_1/FVC. MMF differences are also significantly different in these students.

Table 20. Symptomatic A conditions for children reporting at Seiberling school ($\bar{x} \pm SE$).

	Baseline	ARI	Δ	N	P
FVC	2.517 ± .036	2.396 ± .037	.121 ± .012	76	.01
FEV_1	2.046 ± .043	1.913 ± .042	.133 ± .020	76	.01
FEV_1/FVC	0.813 ± .009	0.799 ± .009	.014 ± .006	76	.10
MMF	2.394 ± .068	2.156 ± .076	.237 ± .048	76	.01

Table 21. Symptomatic B conditions for children reporting at Seiberling school ($\bar{x} \pm SE$).

	Baseline	ARI	Δ	N	P
FVC	2.522 ± .038	2.386 ± .039	.136 ± .016	70	.01
FEV_1	2.042 ± .046	1.883 ± .045	.159 ± .021	70	.01
FEV_1/FVC	0.808 ± .009	0.790 ± .011	.018 ± .008	70	.05
MMF	2.398 ± .072	2.103 ± .072	.295 ± .040	70	.01

Figures 9, 10, and 11 graphically show comparative differences for FVC, FEV_1 and MMF for both schools during both the symptomatic and asymptomatic testing. In general there are several aspects of these figures worthy of mention.

In comparing the two schools relative to FVC, there were no significant differences during any of the testing phases. This particular variable also showed very poor recovery capacity as the 7-9 day asymptomatic values are still high.

The FEV_1 data begin to diverge a bit from the trends of FVC. First the maximum differences from baseline occur at asymptomatic days 1-3 as in the FVC data, but in this case only for the Seiberling students. The Betty Jane group is on its way to recovery during the asymptomatic phase as would be expected. At asymptomatic days 7-9, however, both groups are very similar. Significant differences between the two groups exist at symptomatic B, and asymptomatic 1-3, and 4-6 ($P < .01$).

Midmaximal flow was the one parameter which showed the largest differences between these two groups of children. Known to be quite sensitive to small airway changes, it is felt that this parameter characterizes the small airway changes in these children in a most definitive manner. From this figure the largest difference from baseline occurs at asymptomatic days 1-3 in the Seiberling group, which is consistent for both FVC and FEV_1 for this group. The Betty Jane group on the other hand, shows a gradual, continuous recovery into asymptomatic days 7-9. The differences between the two groups are all significantly different ($P < .01$) for MMF.

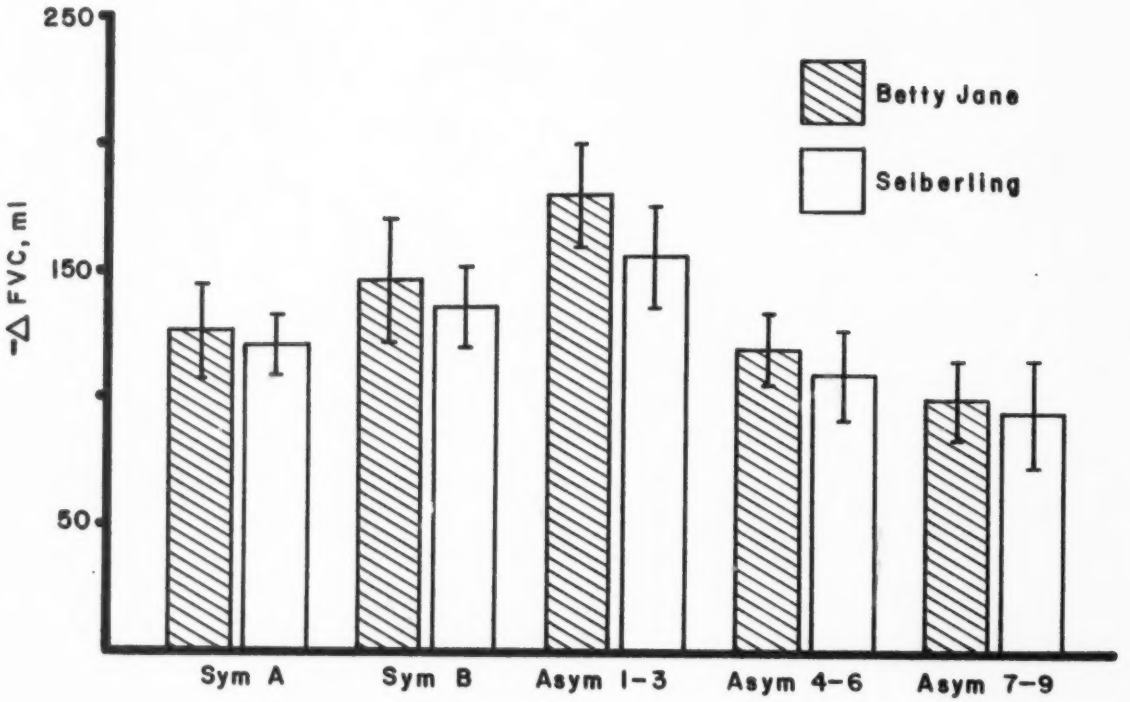

Figure 9 - Comparative differences for forced vital capacity during symptomatic and asymptomatic phases of acute respiratory illness ($\bar{x} \pm SE$).

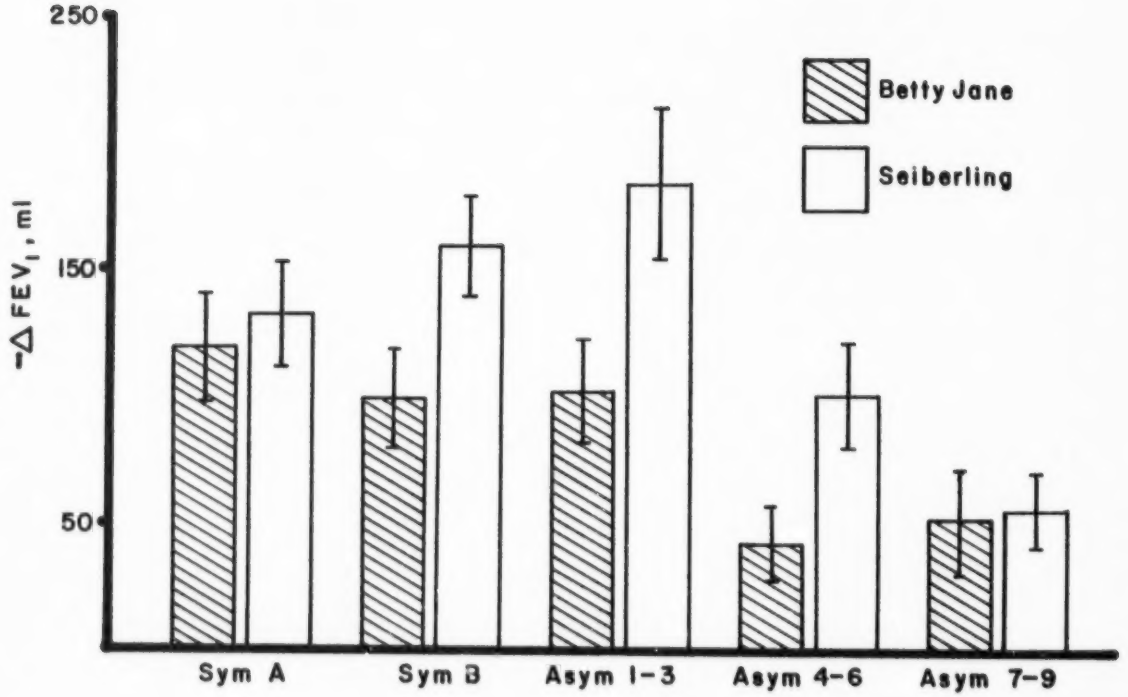

Figure 10 - Comparative differences for forced expiratory volume during symptomatic phases of acute respiratory illness ($\bar{x} \pm SE$).

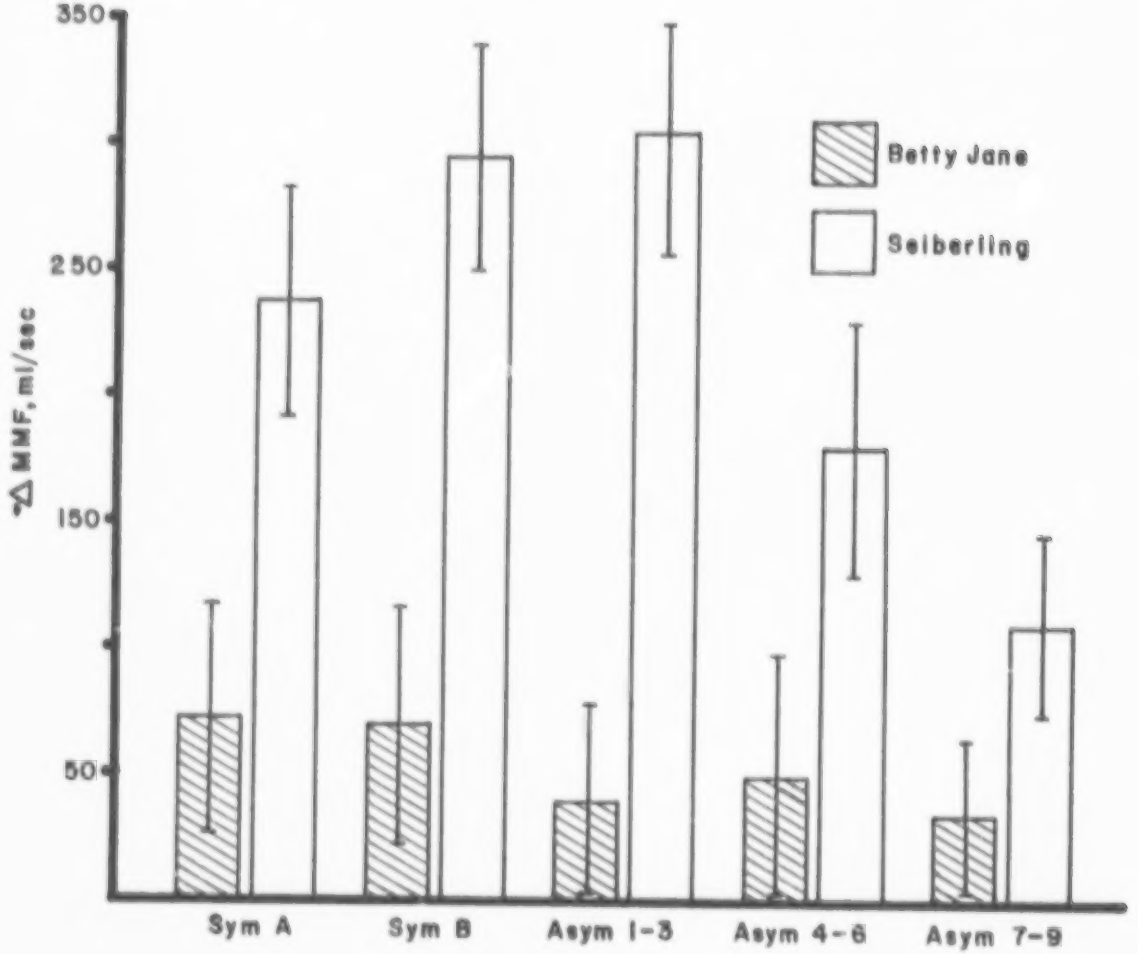

Figure 11 - Comparative differences for midmaximal flow during symptomatic and asymptomatic phases of acute respiratory illness ($\bar{x} \pm SE$).

TRACE METAL ANALYSIS IN HAIR

The trace metal analyses in the hair were done using atomic absorption spectrophotometry. All of the hair was collected in March and April and kept in small paper coin envelopes until analyzed. The results are summarized in Table 22.

Table 22. Summary of trace elements in the hair (1977), all data are given in parts per million (ppm), ($\bar{x} \pm SE$).

	Pb	Cd	Hg	Se	As
Seiberling Males N=84	17.52±1.52*	0.98±.05ns	17.68±0.32*	0.85±.06ns	1.02±.06ns
Seiberling Females N=74	13.69±1.41ns	0.81±.05*	17.25±0.34*	0.75±.05ns	1.02±.06ns
Betty Jane Males N=107	11.51±1.11	1.00±.04	14.63±0.31	0.70±.03	0.95±.05
Betty Jane Females N=69	14.91±1.3	1.07±.04	14.31±0.34	0.71±.04	1.05±.06

* = $P < .01$
ns = not significant

Beryllium was a metal that was also determined but apparently the detection limit of the procedure used was such that anything less than 1 ppm could not be differentiated. Therefore, these values are not included in Table 22.

The analysis of the trace elements was carried out on these children without the use of strict control measures. One main criticism is that the hair was cut by the parents and the distance from the scalp was not known. In this regard several authors (47, 48) have shown that trace element concentrations can vary along the length of the strand of hair

thereby reflecting variations in exposure.

During the 1978 study we attempted to correct these inconsistencies in hair trace element analysis. The hair was cut by the experimenters at scalp level. From this length of hair, 3 cm was cut as measured from the scalp end. Several clumps were cut so an appropriate amount of hair could be used for atomic absorption analysis. These hair samples were analyzed by Stewart Laboratories and are shown in Table 23. The "t" tests as always are for between school significance.

Table 23. Summary of trace elements in hair (1978), all data are in parts per million (ppm), ($\bar{x} \pm SE$).

	Cd	Hg	Pb
Betty Jane			
Total	n=41 .108 ± .014#	n=41 .235 ± .037ns	n=40 1.172 ± .112**
Male	n=25 .115 ± .014#	n=25 .162 ± .023**	n=25 1.308 ± .158**
Female	n=16 .097 ± .029*	n=16 .282 ± .071ns	n=15 .946 ± .125ns
Seiberling			
Total	n=41 .244 ± .029	n=39 .332 ± .042	n=38 1.993 ± .323
Male	n=22 .289 ± .048	n=20 .329 ± .069	n=21 2.633 ± .531
Female	n=19 .192 ± .029	n=19 .355 ± .057	n=17 1.202 ± .180

* = P<.05 # = P<.01
** = P<.02 ns = not significant

Summarizing the trace metal data, even though there is some statistical significance between the Seiberling and Betty Jane groups, the higher values are not significantly elevated from normal values reported in the literature, and do not appear to pose any health problems.

Referring back to Table 6 one does observe that for each trace metal the comparative aerometric data and hair data follow the same trend within the two geographic areas. This would seem to substantiate the validity of using hair as an indicator for environmental load of trace elements.

This work has succeeded in accomplishing its design objectives by: 1) measuring air pollutants within a given area, 2) measuring a variety of physiological and epidemiological parameters within the selected areas, 3) repeating sampling procedures on the children under several conditions, and 4) utilizing a large sample size. It is felt that the design of this project optimizes the study of the cause and effect relationship between air pollutants and health effects in children, where in the past this has not been accomplished.

The aerometric data proved to be an interesting finding within this study design. The annual average for SO_2 at Seiberling school was about three times the value recorded at the Betty Jane school, and that for NO_2 was about twice the value recorded at Betty Jane. Both of these values are significantly different. Since these differences occurred within a geographical area of about 5 square miles, this proved to be an excellent opportunity to determine if any physiological differences exist. Within such a small geographic area SES differences proved to be nonexistent and facilitated the measurement and determination of differences in lung function tests, questionnaire responses, incidence and severity of ARI, and trace metal accumulation.

Aerometric data interpretation, however, was not without several problems. The first was that levels of TSP did not follow the levels of SO_2.

These two parameters are usually in close agreement because they are given off as a result of sulfur-containing fossil fuel combustion. A likely explanation to this discrepancy is that most plants in the Akron area have installed good particulate emission controls, but poor SO_2 emission controls. At the three stations monitored in Akron during this study the levels of SO_2 were highest during the winter months and levels of TSP were highest during the fall of the year. SO_2 seemed to parallel NO_2 more so than TSP. The correlation coefficient for SO_2 and TSP was .50 while the correlation coefficient for SO_2 and NO_2 was .7 which statistically characterized the pollutant relationship. This could be logical since SO_2 and NO_2 are both produced in the production of high pressure steam. One point of considerable importance is the amount of daily variation about the annual averages. Commonly known as "spiking", such large daily variations could have significant physiological consequences. In this study the most frequent and largest amount of spiking took place at the Seiberling station. Such spiking is often associated with significant health effects such as has been shown in this study.

Even though SO_2 was high in the Seiberling area, the mean levels of suspended sulfates varied very little from month to month. This could be due to the fact that the stations were quite close to the presumed emitting sources and there was very little converted to SO_4. Several studies (49, 50) have shown that the conversion of SO_2 to SO_3 and the reaction to sulfate takes a relatively long time, so that close to the emitting source little conversion has taken place. In 1976, a study conducted during the summer in New York City determined that 75% of the ambient sulfate was transported into the city with prevailing westerly winds (51).

The rates of conversion of SO_2 to sulfate aerosol in power plant plumes is low near the point of emission and increases as ambient air mixes with the plume. Furthermore, the models for SO_2 conversion are only now being developed and currently do not predict levels accurately. Interestingly, SO_2 in plumes near ground level is removed rather rapidly by dry deposition, whereas high level plumes increase the atmospheric residence time of SO_2 which leads to increased atmospheric sulfate formation. The sulfates are then transported several hundred kilometers and may produce air pollution episodes at a distance downwind (49). Therefore, it appears from these data that there is very little surface aerosol production from the SO_2 emissions in the Akron area. This could account for the constancy and similarity of the suspended sulfate and suspended nitrate values in the study area.

In this work the levels of SO_2 are not exceedingly high, but the annual average value does approach the Federal secondary annual standard of 60 ug/m^3. Available literature seems to indicate that values of at least 80 ug/m^3 are effective in producing only human annoyance effects and most likely would not produce any reductions in pulmonary functions (52). This same value of 80 ug/m^3 is assumed to be associated with aggravating chronic obstructive lung disease (COLD)(53). Baseline pulmonary function testing done in this work is in agreement with above statements, since we found no differences in any of the PFT parameters recorded during asymptomatic conditions. We did, however, find reductions in the value FEV_1/FVC in the Seiberling children. This ratio represents that portion of the vital capacity that can be forcefully expired within the first second of a forced expiration. It is quite sensitive to changes in small

airway integrity and in the past has been shown to be a very effective predictor of small airway disease (43). This reduction of the FEV_1/FVC ratio is considered to be a significant finding in this study. As stated before, the levels of pollutants are not alarmingly high and such would not be expected to adversely affect lung functions. However, in testing these children over a two year period of time we consistently found a reduced FEV_1/FVC ratio for children in the area with the highest pollutant levels. This particular parameter when considered alone might be overlooked as a minor effect since the differences are small, and the levels of statistical significance are at the 0.1 level of probability. However, when these data are coupled with the results of the ARI work, one can begin to envision an impending problem.

The ARI data did produce several significant findings. The first is the number and severity of the ARI's in the children at the Seiberling school. We found a higher number of children reporting ARI's at Seiberling as compared to Betty Jane. This fact also corresponds well with the daily symptoms data where we also found a high incidence of daily symptoms at Seiberling.

In both schools we found a significant reduction in FVC, FEV_1, and MMF when compared to baseline values (Tables 18, 19, 20, and 21). Of greater significance, when we compared these differences from baseline values between the two schools, the Seiberling children had a significantly greater reduction in FEV_1 and MMF than the Betty Jane children. Examination of the PFT histograms (Figures 9, 10, and 11), would indicate that lung functions were slower to return to the original baseline values, especially for MMF. MMF was the parameter most affected

by the ARI's. In the past this value has been used to be a sensitive indicator of changes in small airway function. From the results of this study, it would appear that the ARI had a most profound effect on the small airways of the Seiberling children. If one refers back to the discussion concerning the significance of the FEV_1/FVC ratio as related to baseline data, the impact of that discussion can now be expanded. We suggest that the higher levels of SO_2 and NO_2 are exerting a low level chronic effect on these children and producing the reduction in the FEV_1/FVC. The superimposition of the ARI produces a compounding of the exacerbation which reflects itself in the highly significant reduction in the values of FEV_1 and MMF. In theory, this is in agreement with other authors (54) and in a real sense has been shown to occur in smokers (55, 56). To our knowledge, such data related to air pollutants have not been presented previously.

A second substantiating finding is the number of reported daily symptoms and questionnaire responses in the Seiberling children. On a daily percentage basis, the Seiberling children report nearly twice as many upper and lower respiratory symptoms than the Betty Jane children. In filling out the questionnaires, the Seiberling parents report that their children have more wheezing and shortness of breath than their counterparts at the Betty Jane school.

Selection processes are constantly occurring in communities with high levels of air pollution. Those adults with a chronic respiratory problem are often advised to leave the area in favor of a more moderate climate and preferably one with lower levels of air pollutants. Thus in studies dealing with adults one always has to ask whether the population

being studied is a true cross section or a selected group which is resistant to the pollutants and free of obstructive pulmonary diseases.

In children, this is usually not the case as they take up residence in the area of parental employment and only in cases of severe pediatric respiratory problems do parents move the family away. Low level chronic symptoms or high incidences and an increase in the severity of ARI's are tolerated or usually overlooked and assumed to be peculiar to a given child. In reality these subclinical chronic symptoms associated with air pollution could well be the forerunner of other more complicated and debilitating problems of COLD in adulthood. In this respect Burrows (57) has reported the pediatric respiratory illness represents a risk factor for the development of COLD in adulthood. Reid (58) has also suggested that air pollution exposure and the accompanying ARI and reduced lung functions could lead to COLD in adulthood.

The term threshold is one which is often used in air pollution research. There are many variations of threshold as evidenced by the Primary and Secondary Standards as well as the PSI which were introduced earlier in this report (Tables 1 and 2). Of primary interest within the context of this report is the lowest threshold or the Primary Standards for SO_2 and NO_2. The data reported in this study all point to the fact that the Primary Standard for both of these variables are capable of producing low level pulmonary abnormalities and therefore are currently too high. The annual average for SO_2 that the Seiberling children were exposed to are closer to the Ohio Standard than the Primary Standard but there are still significant pulmonary problems.

NO_2 values reported in this work are much lower than the Primary

Standard and at this level there are no health effects reported in the literature. It is suggested that the effects could be synergistic with SO_2 and as such the problem deserves serious consideration.

On the basis of these observations, we recommend that the standard for SO_2 should be reduced from the present acceptable levels, and until further data are available, the levels of NO_2 should remain unchanged.

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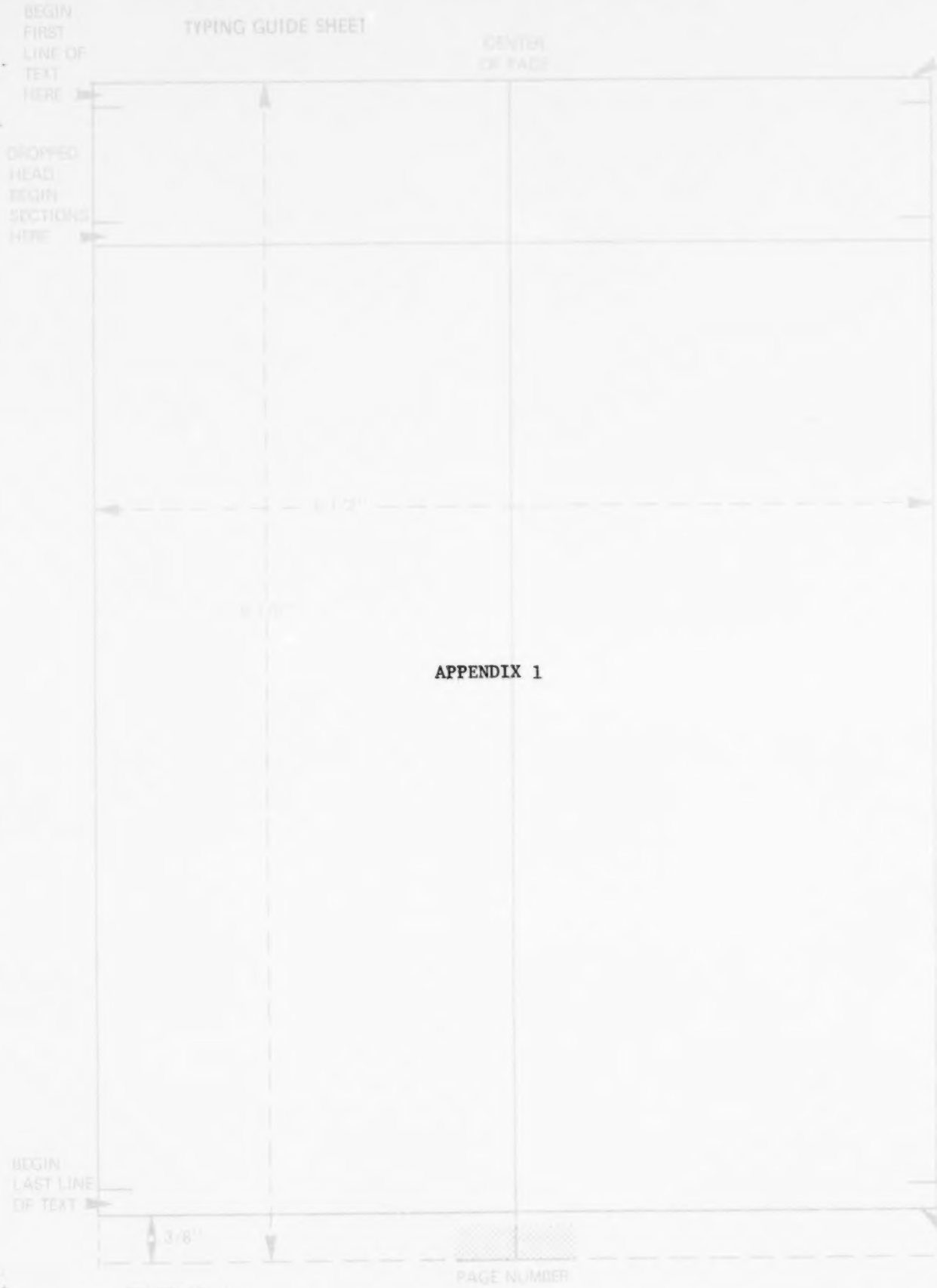
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APPENDIX 1

THE UNIVERSITY OF AKRON
AKRON, OHIO 44325

Department of Biology
Phone: (216) 375-7155

Dear Parent:

This letter is provided to give you a general idea concerning the project that we are asking you and your child to participate in.

Very briefly, we are seeking volunteers to assist us in answering a number of questions about respiratory problems in northeastern Ohio. By volunteering, your child will be one of several thousand participating in our project.

Our research in Akron involves three things: 1) the completion of a questionnaire, 2) pulmonary function testing, 3) testing for trace metals in hair, and 4) blood pressure. Pulmonary function testing is a test that involves your son or daughter blowing into a tube and we measure the volume of air and the speed with which it was blown into the tube. There are absolutely no risks whatsoever involved with this test; it is perfectly safe. Tests of this type are administered millions of times each day around the world to people of all ages. The only purpose is to see how much air an individual can blow out and in what period of time. Determination of trace metals such as lead, cadmium, beryllium and mercury will be carried out on hair samples.

All of the work has been reviewed, funded, and is sponsored by the United States Environmental Protection Agency (EPA), Washington, D.C. The individuals primarily involved in setting up and carrying out this project are Drs. Richard Mostardi, and Daniel Ely from the University of Akron. If you have any questions concerning any aspect of this project, please do not hesitate to ask. We will be more than happy to provide additional information.

We look forward to having your child participate, and through his or her participation we hope we can answer some of the important questions concerning respiratory problems in children.

Sincerely,

Richard A. Mostardi, Ph.D.
Associate Professor

University of Akron Research Study on
Respiratory Disease

Pediatric Questionnaire I - 1976-77

We would like the questionnaire to be completed by the parent of each child participating in the study. The questions can be answered by circling the number of the best answer or by filling in a blank with a number or word. All questions in this questionnaire concern only your child. Please try to answer all questions as completely as possible.

ALL INFORMATION WILL BE KEPT CONFIDENTIAL

Name_____QID_____

Address_____

Phone_____

Child's date of birth_____

1. Date questionnaire completed _____ _____ _____
(month) (day) (year)

2. During the past two years has this child had:
(If uncertain, circle NO)

a. any kind of heart trouble?
1. YES
2. NO

b. high blood pressure?
1. YES
2. NO

3. Does this child have a cough when he or she doesn't have a cold?
(Either first thing in the morning or at any other time of the day.)
1. YES
2. NO

If YES to 3, proceed to 3a:

a. At what time of day does this cough usually occur?
(Circle correct answer(s).)
1. In the morning (shortly after rising)
2. Later in the morning
3. Afternoon
4. Evening
5. During the night
6. No relation to time of day

b. Are there any months in which this child coughs on most days?
1. YES
2. NO

If YES, please specify the number of months per year.
_____(months)

c. Circle the months in which the cough is usually most severe.

or____check here if no relation to time of year.

1	2	3	4	5	6	7	8	9	10	11	12
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

c. Circle the months in which this is usually most severe. or____check here if no relation to time of year

1	2	3	4	5	6	7	8	9	10	11	12
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

d. For how many years has he or she raised phlegm, sputum, or mucous from the chest?

1. Less than 2 years
2. 2-5 years
3. More than 5 years

e. Does the weather affect this condition?

1. YES
2. NO

f. Does this child raise more or less phlegm, sputum, mucous, or any type of fluid from the chest now than two years ago?

1. More
2. Less
3. No change

g. During the past two years, has he or she seen a doctor about this condition?

1. YES
2. NO

5. Does this child's chest ever sound wheezy or whistling?

If YES to 5, proceed to 5a:

a. Does he or she get this with colds?

1. YES
2. NO

b. Does he or she get this even without having a cold?

1. YES
2. NO

c. Does he or she have a wheezy sound on most days?

1. YES
2. NO

6. Has this child ever had attacks of shortness of breath with wheezing?

1. YES
2. NO

d. For how many years has he or she had a cough?

1. Less than 2 years
2. 2-5 years
3. More than 5 years

e. Does the weather affect the cough?

1. YES
2. NO

f. Does this child cough more or less now than two years ago?

1. More
2. Less
3. No change

g. During the past two years, has he or she seen a doctor about the cough?

1. YES
2. NO

4. Does this child ever bring up phlegm (flem), sputum, mucous, or any type of fluid from the chest when he or she doesn't have a cold? (Either first thing in the morning or at any other time of the day.)

1. YES
2. NO

If YES to 4, proceed to 4a:

a. At what time of day does this usually occur? (Circle correct answer(s).)

1. In the morning (shortly after rising)
2. Later in the morning
3. Afternoon
4. Evening
5. During the night
6. No relation to time of day

b. Are there any months in which he or she brings up phlegm, sputum, or mucous from the chest on most days?

1. YES
2. NO

If YES, please indicate the number of months per year

_____(months)

If YES to 6, proceed to 6a:

a. Does he or she get this with colds?
   1. YES
   2. NO

b. Does he or she get this even without having a cold?
   1. YES
   2. NO

c. During the past year, how many attacks of shortness of breath with wheezing did this child have?
   1. None
   2. A few (1-3)
   3. Several (4-10)
   4. Many (11 or more)

d. How old was this child when he or she had the first such attack? _____(age)

e. How old was this child when he or she had the last such attack? (If he or she still has attacks, indicate present age). _____(age)

7. Where would you like this child's test results from this study sent?
   1. Doctor
   2. Myself
   3. Nowhere
   4. Doctor & Myself

8. What is the doctor's name and location:

_____Name

_____Address

_____City, State, Zip

University of Akron Research Study on
Respiratory Disease

Pediatric Questionnaire II - 1976-1977

We would like the questionnaire to be completed by the parent of each child participating in the study. The questions can be answered by circling the number of the best answer or by filling in a blank with a number or word. All questions in this questionnaire concern only your child. Please try to answer all questions as completely as possible.

ALL INFORMATION WILL BE KEPT CONFIDENTIAL

Name_____QID_____

Address_____

Phone_____

Child's date of birth_____

1. Date questionnaire completed? _____ (month) _____ (day), _____ (year)

2. Does this child suffer from shortness of breath while walking?
   1. YES
   2. NO

3. Does this child suffer from shortness of breath while playing?
   1. YES
   2. NO

4. Does this child ever stop to catch his breath while walking?
   1. YES
   2. NO

5. Does this child ever stop to catch his breath while playing?
   1. YES
   2. NO

6. Does this child get short of breath walking with other children the same age on level ground?
   1. YES
   2. NO

7. Does this child have to stop for breath while walking at his or her own pace on level ground?
   1. YES
   2. NO

8. Does he or she become short of breath, during normal play, more often now than two years ago?
   1. YES
   2. NO

9. During the past two years, has this child seen a doctor because of shortness of breath?
   1. YES
   2. NO

10. During the past two years, how often was this child <u>unable</u> to do his or her usual activities because of illnesses such as chest cold, bronchitis, or pneumonia? (Does not refer to head colds.)
   1. Never
   2. During 1 such illness
   3. During 2-5 such illnesses
   4. During 6 or more illnesses

11. During the past year, how many days has this child been unable to do his or her usual activities because of such illnesses? _____(days)

12. During the past year, has this child seen a doctor for: (Consult your physician if you are unfamiliar with these terms.)

a. Emphysema? 1. YES 2. NO

b. Chronic bronchitis? 1. YES 2. NO

c. Bronchiectasis? 1. YES 2. NO

d. Asthma? 1. YES 2. NO

e. Sinus trouble? 1. YES 2. NO

f. Pneumonia? 1. YES 2. NO

g. Acute bronchitis? 1. YES 2. NO

h. Asthmatic bronchitis? 1. YES 2. NO

i. Bronchiolitis? 1. YES 2. NO

j. Croup? 1. YES 2. NO

k. Whooping cough? 1. YES 2. NO

l. Eczema? 1. YES 2. NO

m. Any other respiratory disease? 1. YES 2. NO

If YES, specify _____

13. Has this child ever had hay fever or any other condition that makes the nose runny or stuffy apart from colds?
    1. YES
    2. NO

If YES to 13, Proceed to 13a.

a. How old was this child when this condition was first noticed? _____(age)

b. How old was this child when he or she last had this condition? (If he or she still has it indicate present age.) _____(age)

c. Has a doctor ever said this condition was due to an allergy?
    1. YES
    2. NO

14. During the past year, has he or she had an allergic reaction to any food or medicine?
    1. YES
    2. NO

15. During the past year, has this child received allergy shots? (Does not refer to allergy skin tests.)
    1. YES
    2. NO

16. Is this child ever troubled by redness, itching, or burning of the eyes?
    1. YES
    2. NO

If YES to 16, proceed to 16a.

a. Circle the months in which these eye symptoms are most severe. or____check here if no relation to time of year

1	2	3	4	5	6	7	8	9	10	11	12
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

b. Does he or she have this on most days for at least one month of the year?
1. YES
2. NO

c. Do you think this eye problem is due to an allergy?
1. YES
2. NO

d. Has a doctor ever said it was due to an allergy?
1. YES
2. NO

17. During the past year, has this child had a chest x-ray?
1. YES
2. NO

18. During the past year, has this child been hospitalized for any heart or lung problem?
1. YES
2. NO

19. Has this child ever had any heart or lung surgery?
1. YES
2. NO

20. Where would you like this child's test results from this study sent?
1. Doctor
2. Myself
3. Nowhere

21. What is the doctor's name and location?

_____ Name

_____ Address

_____ City, State, Zip

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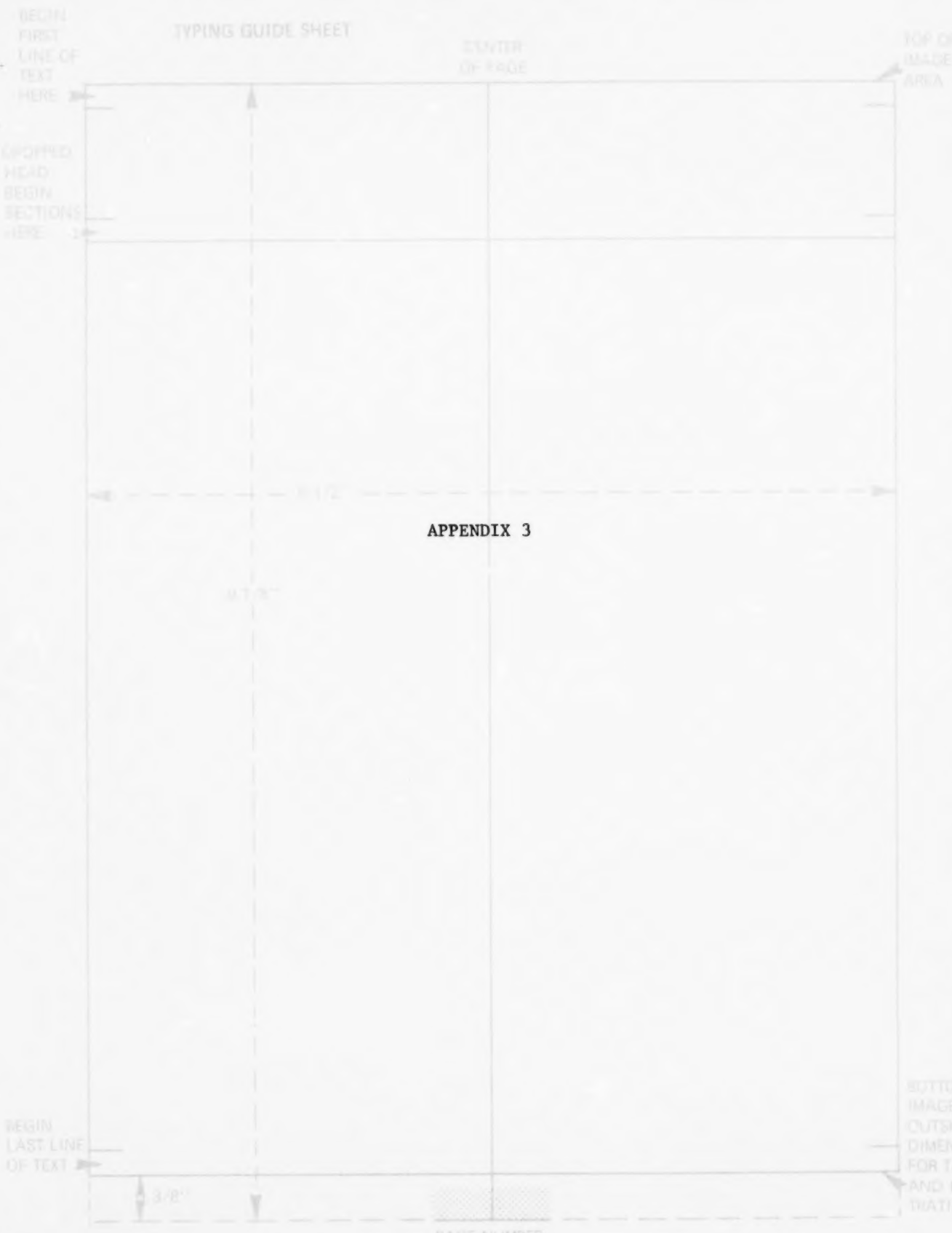
APPENDIX 2

Name_____ Home Room_____ Week_____

	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Cough							
Stuffy or Runny Nose							
Sore Throat							
Chest Congestion (wheezy chest)							
Eye Irritation							
Cold							

Name_____ Home Room_____ Week_____

	Saturday		Sunday		Monday		Tuesday		Wednesday		Thursday		Friday	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Cough														
Stuffy or Runny Nose														
Sore Throat														
Chest Congestion (wheezy chest)														
Eye Irritation														
Cold														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APPENDIX 3

THE UNIVERSITY OF AKRON
AKRON, OHIO 44325

Department of Biology
Phone: (216) 375-7155

Dear Parent:

Thank you very much for allowing your child to participate in our research project last year. During this time we learned a great deal about respiratory disease in young people. As is always the case, however, we are eager to learn more. To this point, we are continuing with the very same type of pulmonary function tests this year that we did on your child last year. As before, these tests were conducted during the school day.

Also we will be asking your child to fill out a symptom chart each day during the home room period in school. A copy of this is enclosed for your information. Each day the child will check the appropriate box indicating what symptom he has and this will enable us to follow his or her respiratory conditions during the year. Also from time to time we may be calling you to verify the symptom, or symptoms, that the child has checked. Many times the children just like to check these boxes and when we see a lot of boxes checked we like to get back to the parent.

Enclosed in the packet you will find two questionnaires concerning details on your child's health during the past year. Please fill out both questionnaires carefully and completely. Also you will find the symptom chart which is for your examination only, throw it out after you have looked at it.

Once again, I can't thank you enough for assisting us in this important work. It is only through mutual cooperation that we shall be able to learn more about respiratory problems and thus how to deal with them.

Sincerely,

Richard A. Mostardi, Ph.D.
Associate Professor

University of Akron Research Study on
Respiratory Disease

PEDIATRIC QUESTIONNAIRE I - 1977-78

We would like the questionnaire to be completed by the parent of each child participating in the study. The questions can be answered by circling the number of the best answer or by filling in a blank with a number or word. All questions in this questionnaire concern only your child. Please try to answer all questions as completely as possible.

ALL INFORMATION WILL BE KEPT CONFIDENTIAL

Name_____ID_____

Address_____

City, State, Zip Code_____Phone_____

Child's date of birth_____Sex_____

1. Date questionnaire completed? _____ _____ _____
(month) (day) (year)

2. During the past year, has this child had: (If uncertain, circle NO)

a. any kind of heart trouble?
1. YES
2. NO

b. high blood pressure?
1. YES
2. NO

3. Does this child have a cough when he or she doesn't have a cold? (Either first thing in the morning or at any other time of the day.)
1. YES
2. NO

If YES to 3, proceed to 3a:

a. At what time of the day does this cough usually occur?
1. In the morning (shortly after rising)
2. Later in the morning
3. Afternoon
4. Evening
5. During the night
6. No relation to time of day

b. Are there any months in which this child coughs on most days?
1. YES
2. NO

If YES, please specify the number of months per year.
_____(months)

c. For how many years has he or she had a cough?
1. Less than 2 years
2. 2-5 years
3. More than 5 years

d. Does the weather affect the cough?
1. YES
2. NO

e. Circle the months in which the cough is usually most severe. or____check here if no relation to time of year.

1	2	3	4	5	6	7	8	9	10	11	12
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

f. Does this child cough more or less now than one year ago?

1. More
2. Less
3. No change

g. During the past year, has he or she seen a doctor about the cough?

1. YES
2. NO

4. Does this child ever bring up phlegm (flem), sputum, mucous or any type of fluid from the chest when he or she doesn't have a cold? (Either first thing in the morning or at any other time of the day.)

1. YES
2. NO

If YES to 4, proceed to 4a:

a. At what time of day does this usually occur? (Circle correct answer(s).)

1. In the morning (shortly after rising)
2. Later in the morning
3. Afternoon
4. Evening
5. During the night
6. No relation to time of day

b. Are there any months in which he or she brings up phlegm, sputum, or mucous from the chest on most days?

1. YES
2. NO

If YES, please indicate the number of months per year. _____(months)

c. Circle the months in which this is usually most severe. or____check here if no relation to time of year.

1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec

d. For how many years has he or she raised phlegm, sputum, or mucous from the chest?

1. Less than 2 years
2. 2-5 years
3. More than 5 years

e. Does the weather affect this condition?

1. YES
2. NO

f. During the past year, did this child raise more or less phlegm, sputum, mucous, or any type of fluid from the chest now than he or she did in the previous year?

1. More
2. Less
3. No change

g. During the past year, how much sputum did this child raise each day?

1. None
2. Less than a teaspoon
3. One teaspoon to 1/4 cup
4. More than 1/4 cup

h. During the past year, has he or she seen a doctor about this condition?

1. YES
2. NO

i. During the past year, how often was the child's sputum yellow or greenish in color?

1. Never
2. Rarely
3. Occasionally
4. Often
5. Very often

5. Does this child's chest ever sound wheezy or whistling?

1. YES
2. NO

If YES to 5, proceed to 5a:

a. Does he or she get this with colds?

1. YES
2. NO

b. Does he or she get this even without having a cold?

1. YES
2. NO

c. Does this child also have a runny or stuffy nose at the time his or her chest is wheezy or whistling?

1. YES
2. NO

d. Does he or she have a wheezy sound on most days?

1. YES
2. NO

e. During the past year, has the child's wheezing or whistling improved, worsened or stayed the same?

1. Improved
2. Worsened
3. Stayed the same

6. Has this child ever had attacks of shortness of breath with wheezing?

1. YES
2. NO

If YES to 6, proceed to 6a:

a. Does he or she get this with colds?

1. YES
2. NO

b. Does he or she get this even without having a cold?

1. YES
2. NO

c. During the past year, how many attacks of shortness of breath with wheezing did this child have?

1. None
2. A few (1-3)
3. Several (4-10)
4. Many (11 or more)

d. During the past year, has this child's symptoms improved, worsened, or stayed the same?

1. Improved
2. Worsened
3. Stayed the same

e. During the past year, has this child had a period as long as two weeks in which he or she had no breathing problems at all even with exercise?

1. YES
2. NO

f. How old was this child when he or she had the first such attack?

_____(age)

g. How old was this child when he or she had the last such attack? (If he or she still has attacks, indicate present age.)

_____(age)

7. Does anyone in this child's house smoke?

1. YES
2. NO

If YES to 7, proceed to 7a:

a. If cigarettes, how many cigarettes per day?

_____
number per day

b. If cigars, how many per day?

_____
number per day

c. If pipes, how many bowls full per day?

_____
number per day

University of Akron Research Study on
Respiratory Disease

PEDIATRIC QUESTIONNAIRE II - 1977-1978

ALL INFORMATION WILL BE KEPT CONFIDENTIAL

Name_____ID_____

Address_____

City, State, Zip Code_____Phone_____

Child's date of birth_____Sex_____

1. Date questionnaire completed? _____ (month) _____ (day) _____ (year)

2. Does this child suffer from shortness of breath while walking?
   1. YES
   2. NO

3. Does this child suffer from shortness of breath while playing?
   1. YES
   2. NO

4. Does this child ever stop to catch his breath while walking?
   1. YES
   2. NO

5. Does this child ever stop to catch his breath while playing?
   1. YES
   2. NO

6. Is this child troubled by shortness of breath when hurrying on level ground or walking up a slight hill?
   1. YES
   2. NO

7. Does this child get short of breath while walking at his or her own pace on level ground?
   1. YES
   2. NO

8. Does this child have to stop for breath while walking at his or her own pace on level ground?
   1. YES
   2. NO

9. Does he or she become short of breath during normal play, more often now than one year ago?
   1. YES
   2. NO

10. During the past year, has this child seen a doctor because of shortness of breath?
    1. YES
    2. NO

11. During the past year, how often was this child unable to do his or her usual activities because of illness such as chest colds, bronchitis, or pneumonia? (Does not refer to head colds.)

1. Never
2. Duri g 1 such illness
3. During 2-5 such illnesses
4. During 6 or more illnesses

12. During the past year, how many days has this child been unable to do his or her usual activities because of such illnesses?

_____(days)

13. During the past year, has this child seen a doctor for: (Consult your physician if you are unfamiliar with these terms.)

a. bronchiectasis
1. YES
2. NO

b. sinus trouble
1. YES
2. NO

c. pneumonia
1. YES
2. NO

d. acute bronchitis
1. YES
2. NO

e. asthmatic bronchitis
1. YES
2. NO

f. bronchiolitis
1. YES
2. NO

g. croup

h. any other respiratory disease
If YES, please specify_____
1. YES
2. NO

14. Has this child ever seen a doctor for chronic bronchitis?
1. YES
2. NO

If YES to 14, proceed to 14a:

a. During the past year, have his or her symptoms improved, worsened, or stayed the same?

1. Improved
2. Worsened
3. Stayed the same

b. Has this child had treatment or medication for chronic bronchitis?

1. YES
2. NO

15. Has this child ever seen a doctor for asthma?

1. YES
2. NO

If YES to 15, proceed to 15a:

a. During the past year, has this child's symptoms improved, worsened, or stayed the same?

1. Improved
2. Worsened
3. Stayed the same

b. During the past year, has this child had a period as long as two weeks in which he or she had no breathing problem at all, even with exercise?

1. YES
2. NO

c. How quickly are this child's attacks usually relieved by treatment?

1. Within minutes
2. Within hours
3. Within days
4. Not relieved
5. No treatment used

16. Has this child ever had hay fever or any other condition that makes the nose runny or stuffy apart from colds?

1. YES
2. NO

If YES to 16, proceed to 16a:

a. How old was this child when this condition was first noticed?

_____(age)

b. How old was this child when he or she last had this condition? (If he or she still has it, indicate present age.) _____(age)

c. <u>During the past year</u>, has this child seen a doctor about it?
1. YES
2. NO

d. <u>During the past year</u>, how much has the child been bothered by it?
1 2 3 4 5
never very often
(circle appropriate number)

17. <u>During the past year</u>, has he or she had an allergic reaction to any food or medicine?
1. YES
2. NO

18. <u>During the past year</u>, has this child received allergy shots? (Does not refer to allergy skin tests.)
1. YES
2. NO

19. <u>During the past year</u>, has this child ever been troubled by redness, itching, or burning of the eyes?
1. YES
2. NO

If YES to 19, proceed to 19a:

a. Circle the months in which these eye symptoms are most severe. or____check here if no relation to time of year.

1	2	3	4	5	6	7	8	9	10	11	12
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

b. Does he or she have this on most days for at least one month of the year?
1. YES
2. NO

c. Do you think this eye problem is due to an allergy?
1. YES
2. NO

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d. Has a doctor ever said it was due to an allergy?
   1. YES
   2. NO

20. During the past year, has this child had a chest x-ray?
   1. YES
   2. NO

21. During the past year, has this child been hospitalized for any heart or lung problem?
   1. YES
   2. NO

22. During the past year, has this child had any other serious illness? If YES, specify what illness_____
   1. YES
   2. NO

23. Where would you like this child's test results from this study sent?
   1. Doctor
   2. Myself
   3. Nowhere

24. What is the doctor's name and address:

_____Name

_____Address

_____City, State, Zip Code

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